AN INVESTIGATION: U. S. IMPORT DEPENDENCE FOR MINERAL RESOURCES, "SUPER" BULK CARRIERS, AND DEEPWATER PORT DEVELOPMENT

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THESIS

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by

Corydon Rouse Gifford

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The thesis examines the increasing dependence of the United States on foreign sources of major fuel and non-fuel mineral resources which appear to have potential requirements for deep-water ports and terminals. Major oceanborne bulk commodity import projections for crude petroleum, iron ore, bauxite, and alumina are presented. Principal bulk commodity ports are identified and major commodity movements are discussed. Past

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and possible future trends in the construction of large ocean bulk carriers are reviewed. Construction and transportation economies available via "super" bulk carriers are examined with emphasis on "super" tankers. The primary consequences of a failure to provide United States facilities to accommodate "super" bulk carriers are identified and recent events in U.S. development of deepwater ports are presented. The major conclusion is, the United States, if it is to maintain its status as a leading economic power, should utilize the technological efficiency provided by "super" bulk carriers.

An Investigation: U.S. Import Dependence for Mineral Resources, "Super" Bulk Carriers, and Deepwater Port Development

by

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June 1974

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I. INTRODUCTION

The United States, as the world's leading industrial power, is also the world's major consumer of both fuel and non-fuel mineral resources. Since 1945 the population of the United States has approximately doubled; the annual consumption of fuel resources, however, has grown more than two and a half times. [Ref. 1, p.2][1] During this same period the United States consumed more metal ore resources than the entire human race had prior to that time. [Ref. 2, p. 1] Although the United States is still fundamentally self-sufficient in a number of important fuel and non-fuel mineral resources, the era of self-sufficiency appears to be changing to an era of increasing import-dependency.

There appears to have been two primary reasons for the recent technological revolution in the world's shipbuilding industry. First, has been the increasing import-dependence by many of the industrial nations for sources of bulk mineral resources, and second, the two closings of the Suez Canal. As a result of the technological revolution very impressive ships have recently joined the world's merchant fleets to transport both dry and bulk commodities. The most

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[1]Numbers in parentheses designate reference and page numbers. References are listed in the List of References at the end of the paper.

impressive are the very large crude carriers (VLCCs)[2] and the multi-purpose oil/ore and oil/bulk/ore (OBO) carriers. These deep draft "super" bulk carriers have become the work-horses of the world bulk shipping fleet. However, their progressively deeper drafts have rendered many of the world's ports obsolete. In order to capitalize on the economies of scale available via "super" bulk carriers, many of the world's maritime dependent nations have modified existing, or constructed new ports and terminals to accommodate these deep draft vessels. Thus the economies of "super" bulk carriers have enabled Japan and European countries, to depend increasingly on more remote sources of mineral resources.

The United States must compete with countries which have facilities to accommodate "super" bulk carriers. However, the United States, the world's leading industrial power, has yet to provide facilities for these deep draft vessels. The purpose of this thesis is to research: (1) the increasing import-dependence of the United States on foreign sources of major bulk fuel and non-fuel mineral resources which appear to have potential requirements for deepwater ports or terminals, (2) principal bulk commodity ports and commodity movements, (3) trends in the construction of ocean bulk carriers, (4) the economics of "super" bulk carriers, (5) the consequences of the United States not providing adequate facilities

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[2]Oil tankers ranging from 200,000 to 500,000 DWT (dead-weight tons) the carrying capacity of a vessel in tons of 2,240 pounds. It is the difference between the light ship weight and the displacement fully loaded.

to accommodate "super" bulk carriers and (6) recent events pertaining to deepwater port and terminal development by the United States.

II. RESEARCH METHODOLOGY

Research methodology consisted primarily of a literature search. Computerized searches were conducted at the Defense Documentation Center and the Naval Postgraduate School library. In addition all National Technical Information Service indexes were searched for the period January 1970 thru February 1974. Pertinent studies and publications were ordered and reviewed. A periodical and newspaper search was also conducted for the same time period at the Naval Postgraduate School library. A field trip to the San Francisco Bay area was also undertaken. Personal discussions were held with key personnel at the Western Regional Office of the Maritime Administration, the South Pacific Division of the U.S. Army Corps of Engineers and the Marconaflo Division of the Marcona Corporation.

Phone conversations were held with experts on the subject of deepwater port development at the Headquarters of the Maritime Administration; U.S. Army Corps of Engineers, Institute of Water Resources; and the National Oceanic and Atmospheric Administration. There have been numerous comprehensive studies undertaken on the subject of deepwater port development. Appendix A reflects only the major studies of which the author has knowledge. The thesis should in no way be considered as the final word in deepwater port development. The presentation should, however,

serve as a summation of some of the issues which pertain to deepwater port development.

III. UNITED STATES IMPORT-DEPENDENCE FOR MINERAL RESOURCES

A. IMPORT-DEPENDENCE FOR NON-FUEL MINERAL RESOURCES

The United States first became a net importer of metals during the 1920's. By 1970 the United States imported approximately 40% of its metal ore requirements and more than half of its supply of six of 13 basic non-fuel mineral resources required by an industrialized society (aluminum, chromium, manganese, nickel, tin, and zinc). [Ref. 2, p. 1] As indicated in Table I, the United States in 1970, was also import-dependent for many other important non-fuel mineral resources.

According to the Department of the Interior, by 1985, the United States will, most likely, become import-dependent for more than half of its supply of three additional basic non-fuel mineral resources required by an industrialized society (iron, lead, and tungsten). The Department further predicts by the year 2000 three more non-fuel mineral resources will have been added to this growing list (copper, potassium, and sulfur). [Ref. 2, p. 1] If these predictions are correct by the year 2000 the United States will have become import-dependent for over half of its supply of 12 of 13 basic non-fuel mineral resources presently required by an industrialized society. These projections were based on the assumption that consumption requirements would continue to increase in the future. The warning signs

Table I. U.S. Import-Dependence and Share in World Consumption of Major Minerals (in percentages)

	Share of Imports in Primary Mineral Supply		Imports as Percent of Consumption	U.S. Share in World Metal Consumption
	1950	1969	1970	1965-69 Ave.
Aluminum (Bauxite)	66	90	91	50
Antimony	63	89	94	27
Asbestos	100	100	83	-
Beryllium	82	-	51	-
Cadmium	51	68	53	42
Chromium	99	100	100	27
Cobalt	90	95	93	32
Columbium	100	100	100	-
Copper	40	9	6	32
Fluorspar[a]	57	86	78	-
Iron Ore[a]	14	31	33	21
Lead	38	42	38	41
Manganese	77	93	99	13
Mercury	90	58	38	28
Mica	99	100	100	-
Molybdenum	0	0	0	-
Nickel	99	90	87	33
Platinum	93	97	98	43
Rutile	-	-	100	-
Selenium	-	-	29	-
Silver	69	58	27	-
Tantalum	100	100	100	-
Tellurium	-	-	20	-
Tin	99	99	100	22
Tungsten	40	52	-	21
Vanadium	1	26	22	-
Zinc	40	63	59	28

Note: a. Data for 1950 represent share of imports in gross supply in 1955, while data for 1969 represent share of imports in gross supply in 1969.

Source: Alexander Lang, "A Crisis in Critical Commodities," Columbia Journal of World Business, Vol. III No. 1, (Spring 1973), p. 44. (Original Sources-Defense Production Act Progress Report-Nr. 50-Potential Shortages of Ores, Metals, Minerals and Energy Resources, U.S. Government Printing Office, U.S. Department of the Interior, 1971 and Mineral Yearbook 1969, U.S. Department of the Interior, Bureau of Mines, U.S. Government Printing Office, 1971).

are up and there is an obvious need to reorder the consumption requirements of these vital resources.

Of all the non-fuel mineral resources the United States will import in the future iron ore and bauxite/alumina will, most likely, be required in the largest bulk quantities. [Ref. 3, Vol. I, p. 26] In 1969 the United States imported, via ocean bulk carrier, approximately 29 million short tons (MST) of iron ore, 1.8 MST of alumina and 16.3 MST of bauxite. Robert R. Nathan Associates recently predicted the United States annual oceanborne imports of standard iron ore (63% Fe) will, most likely, reach 34.1 MST by 1980 and 48.3 MST by the year 2000.[3] [Ref. 3, Vol. I, p. 26] These projections compare very favorably with predictions recently made by Soros Associates. (See Drawing 1 for Soros Associates predictions of annual oceanborne iron ore imports to the year 2000.)

The United States has recently been importing approximately 50% of its iron ore from Canada, however, much of the Canadian ore is as low grade as Lake Superior ore and is therefore beneficiated and pelletized. Numerous U.S. steel corporations have high grade iron ore holdings in such

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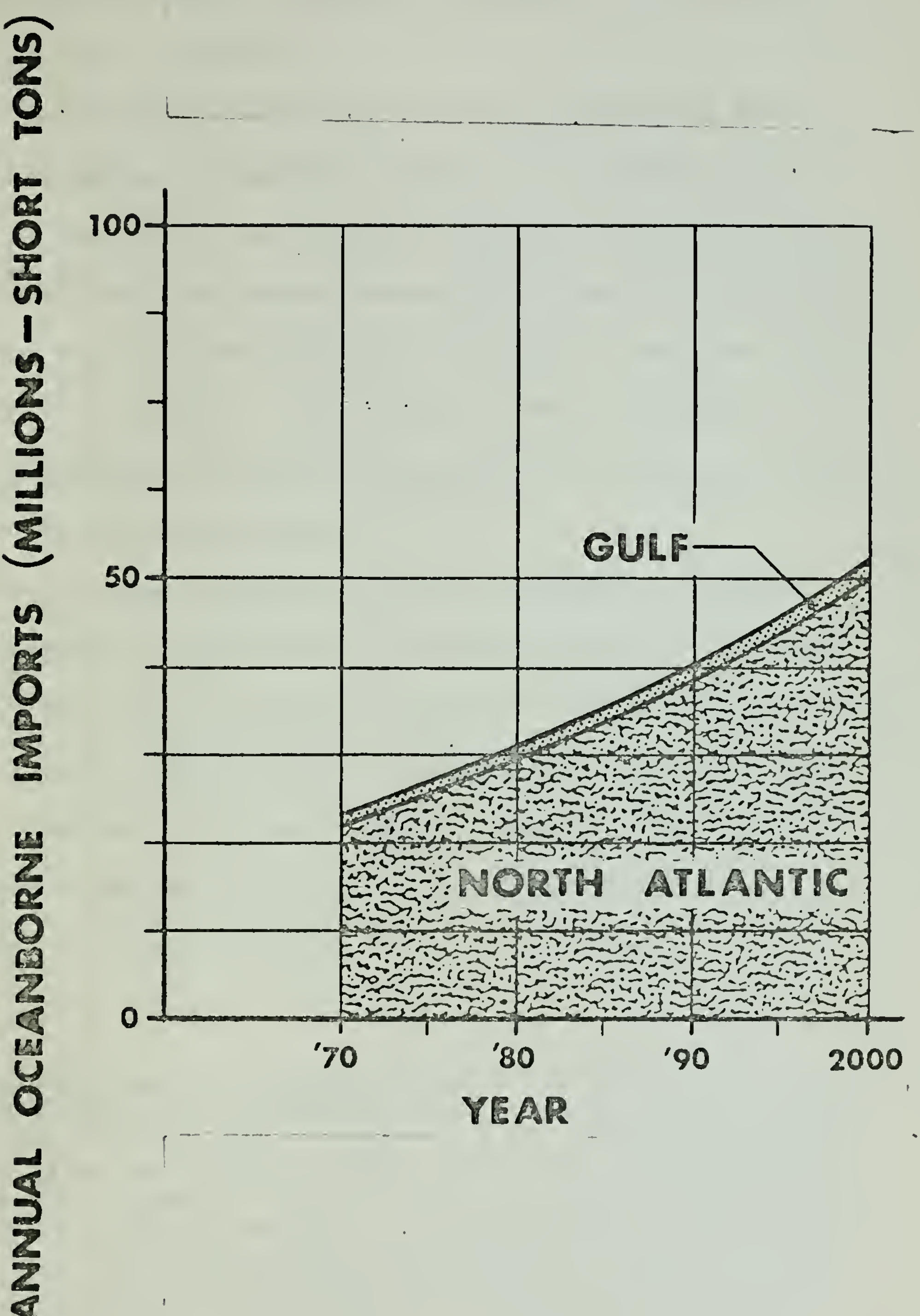
[3]"Key assumptions underlying projections of seaborne imports of iron ore are a compound average growth rate of 2.25 percent from 1970 to 2000 in U.S. consumption of finished steel; continuation of combined raw material and finished product delivery costs as a basic determinant of the location of steel plants for U.S. and Canadian iron ore vis-a-via seaborne imported ore." [Ref. 3, Vol. I, p. 29]

Drawing 1. Projected Annual Oceanborne Imports of Iron Ore to the Year 2000 (millions-short tons)



Source: Soros Associates, Inc. Offshore Terminal System Concepts, prepared for the U.S. Department of Commerce, Maritime Administration, September 1972, Executive Summary Fig. 1-4.

countries as Venezuela, Brazil, Peru, Chile, New Zealand, Liberia, and Australia. In the future these countries are expected to become more important suppliers of iron ore. [Ref. 3, Vol. II, p. 264]

Robert R. Nathan Associates recently predicted the United States annual oceanborne imports of alumina will, most likely, reach 5.7 MST by 1980 and 15.2 MST by the year 2000. Predictions for annual oceanborne imports of alumina are for 15.9 MST by 1980 and for 15.9 MST by the year 2000.[4] [Ref. 3, Vol. I, p. 16] (See Table II and Drawing 2 for other predictions by Stanford Research, Booz-Allen, Litton Systems and Soros Associates.)

In recent years countries in the Caribbean (Jamaica, Dominican Republic, and Haiti) and South America (Surinam and Guyana) have been the major sources of the United States supply of bauxite and alumina. However, in the near future the United States will, most likely, import progressively more bauxite from Australia and Africa (Guinea and Ghana). [Ref. 3, Vol. II, p. 309-310]

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[4]Key assumptions: "Imports of both alumina and bauxite are expected to be constrained by policies of the less developed producing countries requiring the indigenous processing of aluminum raw materials. Other key assumptions underlying the projected imports are that annual growth of U.S. aluminum consumption would progressively decline from 8 percent in 1970 to 4 percent in 1990 and 2000; aluminum imports would increase from approximately 10 percent of consumption in 1970 to 15 percent in 1980 and 27 percent in 2000; and primary aluminum production would increase from roughly 4 million tons in 1970 to 11.5 million tons in 2000." [Ref. 3, Vol. I, p. 29-30]

Table II. Comparative Estimates of U.S. Imports of Bauxite and Alumina

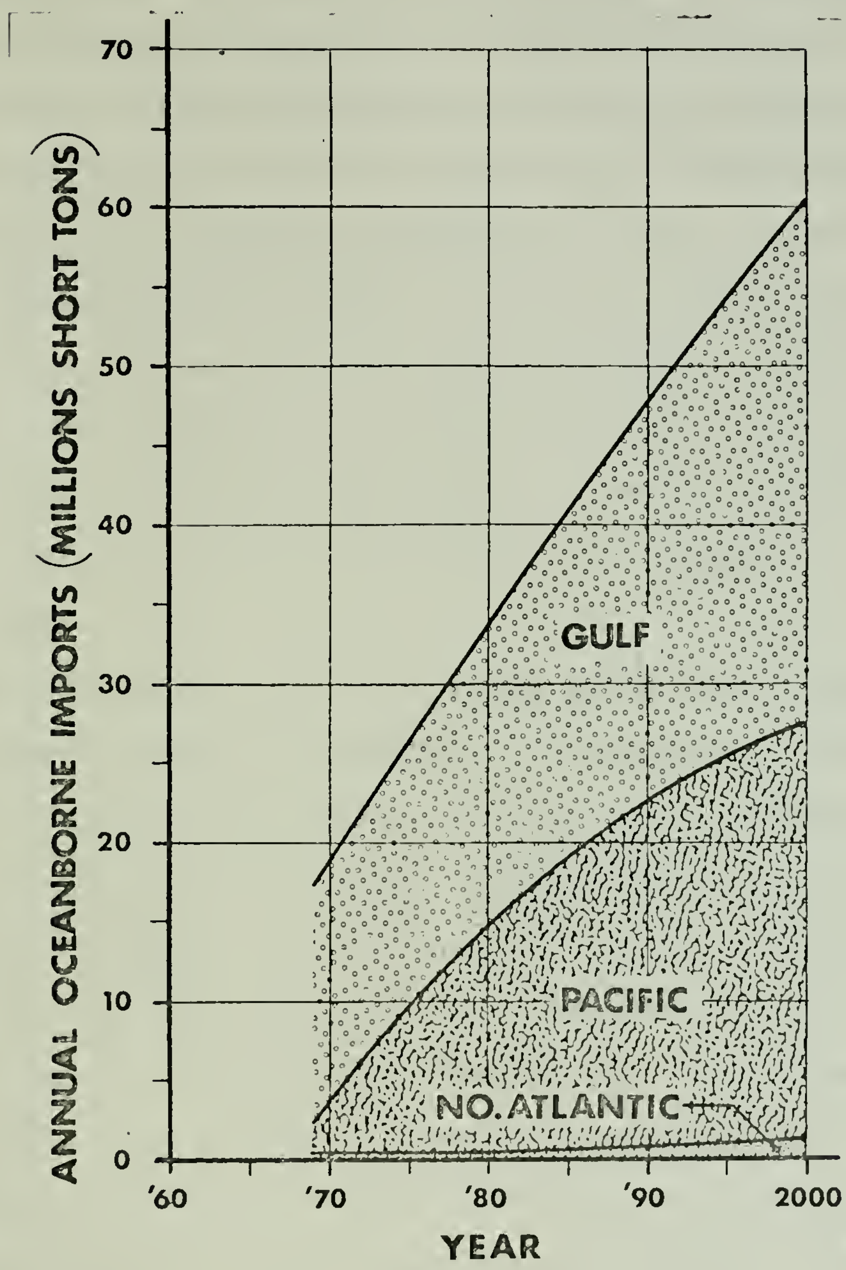
(In millions of short tons)

Estimates	1975	1980	1995	2000
RRNA a/				
Bauxite:				
Probable...............	n.a.	15.9	n.a.	15.9
High...................	n.a.	18.2	n.a.	22.7
Alumina:				
Probable...............	n.a.	5.7	n.a.	15.2
High...................	n.a.	6.5	n.a.	18.0
Stanford Research				
Bauxite and alumina.....	24.1	n.a.	52.7	n.a.
Booz-Allen				
Bauxite:				
Low....................	n.a.	8.0	8.0	n.a.
Medium.................	n.a.	10.5	10.1	n.a.
High...................	n.a.	15.6	17.6	n.a.
Alumina:				
Low....................	n.a.	1.2	1.2	n.a.
Medium.................	n.a.	8.6	18.7	n.a.
High...................	n.a.	17.3	61.7	n.a.
Bureau of Mines	n.a.	n.a.	n.a.	n.a.
Litton Systems				
Bauxite:				
Constant growth........	n.a.	71.3	n.a.	774.3
Adjusted...............	n.a.	34.4	n.a.	77.8

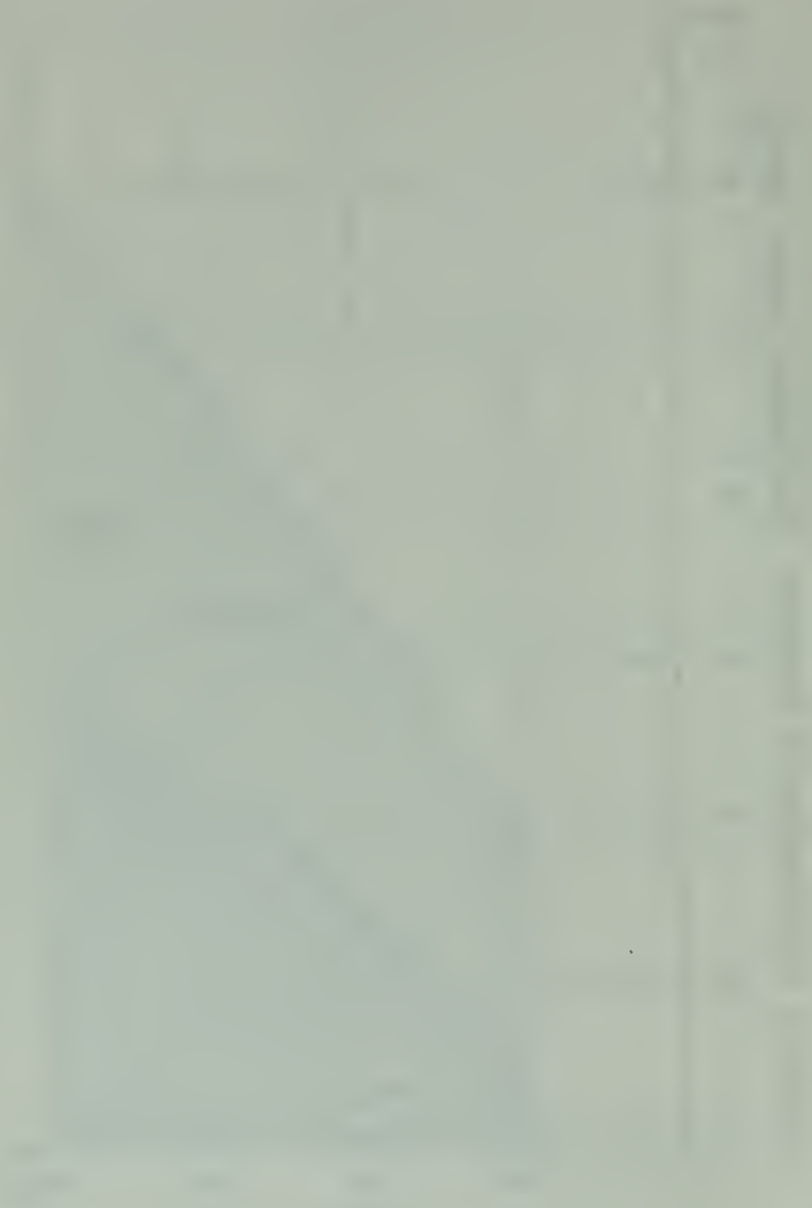
a/ Robert R. Nathan Associates

Source: Robert R. Nathan Associates, U.S. Deepwater Port Study, prepared for U.S. Army Corps of Engineers, August 1972. (Original Sources - Stanford Research Institute, Principal U.S. Dry Bulk Commodity Seaborne Imports and Exports for 1975 and 1995, prepared for U.S. Department of Commerce, Maritime Administration. Booz-Allen Applied Research Inc., Forecast of U.S. Oceanborne Foreign Trade in Dry Bulk Commodities, prepared for U.S. Department of Interior. Litton Systems Inc., Oceanborne Shipping Demand and Technology Forecast, prepared for U.S. Department of Commerce, Maritime Administration.)

Drawing 2. Projected Annual Oceanborne Imports of Bauxite and Alumina to the Year 2000 (millions-short tons)



Source: Soros Associates Inc. Offshore Terminal System Concepts, prepared for the U.S. Department of Commerce, Maritime Administration, September 1972, Executive Summary, Fig. 1-6.



The problem of import-dependence for supplies of non-fuel mineral resources is to a large extent economic. The United States still has large known and potential reserves of many non-fuel mineral resources. However the accessibility and quality of the remaining resources is progressively declining, and the cost of exploration, development, and exploitation are steadily increasing. [Ref. 4, p. 45] The easily accessible high grade iron ore once mined at the Mesabi Range has for the most part been depleted. Copper ore with less than 1% copper is presently being mined in the United States. A decade ago copper ore would not have been mined unless it contained in excess of 2% copper. [Ref. 5, p. 109]

In order to mine progressively lower grade ore, proportionately larger volumes of earth must be disturbed. This problem has been the subject of great controversy between ecologists and the mining industry. There is, of course, another source of metals to be "mined" and this is through recycling. For all the publicity recycling has recently received the results have not been impressive. For example, all the aluminum cans brought to recycling centers have only provided approximately one tenth of the current production needs. There presently are no significant economic incentives in the United States for making large scale recycling financially attractive. [Ref. 5, p. 174] There have recently been numerous suggestions on methods to make recycling financially attractive. Establishing tax incentives

for recycling to compete with the depletion allowance of mined ore and lowering freight rates for recyclable scrap to rates similar to mined ore have been two suggestions. Raising ecological costs in mining operations by requiring the restoration of mined areas to their original condition would also encourage recycling.

B. IMPORT-DEPENDENCE FOR FUEL MINERAL RESOURCES

The United States is the world's major consumer of fuel mineral resources. In 1970 the United States consumed 43% of the energy and 36.7% of the petroleum used in the free world. However, in 1970 the population of the United States comprised only 8.3% of the entire free world population. [Ref. 6, p. 23] In 1971 the United States consumed approximately 5,523 million barrels[5] of petroleum, 22,050 billion cubic feet of natural gas and 510.8 MST of coal. [Ref. 7, p. 18] As indicated in Table III, the Department of the Interior anticipates that the consumption of all three fuel mineral resources will increase in the future.[6]

The United States has vast coal reserves and has for many years been a net exporter. In 1969 the United States exported 56.2 MST of coal and exports increased to 70.9 MST in 1970. [Ref. 1, p. 4] It is anticipated that the United

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[5]All data available from the U.S. Government and industry are expressed in terms of 42 gallon barrels.

[6]These predictions were made in 1972 prior to the Organization of Petroleum Export Countries (OPEC) embargo and their validity is questionable due to the higher cost of petroleum.

Table III. U.S. Consumption of Energy Resources by Major Sources, 1971 Actual, with Projections to the Year 2000

	1971	1975	1980	1985	2000
Petroleum (includes natural gas liquids):					
Million barrels	5,523	6,340	7,615	9,140	12,985
Million barrels per day	15.1	17.4	20.9	25.0	35.6
Trillion Btu	30,492	35,090	42,190	50,700	71,380
Percent of gross energy inputs	44.1	43.8	43.9	43.5	37.2
Natural Gas:					
Billion cubic feet	22,050	24,462	26,169	27,537	32,959
Trillion Btu	22,734	25,220	26,980	28,390	33,980
Percent of gross energy inputs	33.0	31.4	28.1	24.3	17.7
Coal (bituminous, anthracite, lignite):					
Thousand short tons	510,800	565,000	665,000	893,000	1,310,000
Trillion Btu	12,560	13,825	16,140	21,470	31,360
Percent of gross energy inputs	18.2	17.2	16.8	18.4	16.3
Hydropower:					
Billion kilowatt-hours	266.3	350	420	470	700
Trillion Btu	2,798	3,570	3,990	4,320	5,950
Percent of gross energy inputs	4.1	4.4	4.2	3.7	3.1
Nuclear power:					
Billion kilowatt-hours	37.9	240	630	1,130	5,470
Trillion Btu	405	2,560	6,720	11,750	49,230
Percent of gross energy inputs	.6	3.2	7.0	10.1	25.7
Total gross energy inputs:					
Trillion Btu	68,989	80,265	96,020	116,630	191,900

Source: U.S. Department of the Interior - Statement by J. Horton, Assistant Secretary for Land and Water Resources, Department of the Interior before House Merchant Marine and Fisheries Committee, 12 June 1973. (Original source - Department of the Interior, United States Energy Through Year 2000, Government Printing Office, 1972.)

States will remain self-sufficient for supplies of coal in the future. However, the United States is import-dependent for supplies of both natural gas and petroleum. Since the thesis is limited to only those bulk commodities which appear to have a potential requirement for deepwater ports, natural gas import-dependency will not be discussed.

In 1970 the United States was import-dependent for approximately 1.3 million barrels per day (MM B/D) of crude petroleum. [Ref. 3, Vol. II, p. 57] By 1971 crude imports had increased to approximately 3.9 MM B/D. [Ref. 7, p. 18] In 1972 this figure was approximately 4.7 MM B/D; over 25% of the United States crude petroleum requirements. [Ref. 8, p. 781] Robert R. Nathan Associates recently predicted the United States daily oceanborne imports of crude petroleum will, most likely, reach 6.9 MM B/D by 1980 and 19.7 MM B/D by the year 2000.[7,8] [Ref. 3, Vol. II, p. 73] Numerous

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[7]"Projections assume no change in Governmental policies affecting exploration for and development of petroleum and natural gas resources in the United States. The rate of growth of petroleum consumption after 1980 is assumed to decline to an average of 2.1 percent annually from long-term past growth rates of approximately 4 percent. There is a further assumption that the downward trend in the volume of crude petroleum production would be reversed, and that commercial supplies of petroleum products would be available from petroleum shale and synthesis of coal. Should these assumptions prove to be invalid, import requirements would be more or less than projected." [Ref. 4, Vol. I, p. 26-27]

[8]These prediction were made in 1972 prior to the OPEC embargo and their validity is questionable due to the higher cost of petroleum.

projections of United States future crude petroleum import requirements have recently been computed. Table IV contains projected import requirements computed by the Department of the Interior and the National Petroleum Council. (See Drawing 3 for Soros Associates projections to the year 2000.)[9] All projections included have assumed completion of the Alaska pipeline.

As a result of the recent OPEC embargo President Nixon has launched Project Independence, an effort to make the United States self-sufficient in energy resources by 1980. There has, however, been no formal plan revealed as to how this project will be implemented. A recent article in the Wall Street Journal stated, "Achieving energy self-sufficiency by 1980, or even 1985, would impose serious strains and huge costs on the American economy. Project Independence has sweeping implications for the cost of living, government spending, the quality of the environment and the nations economic ties to the rest of the world." [Ref. 9, p. 1] A large number of energy officials within the administration and also in private business believe the 1980 figure is overly optimistic for such a major project. S. David Freedman, a former White House energy policy chief, was recently quoted by the Wall Street Journal as stating, "The 1980 target date is completely unrealistic!" [Ref. 9,

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[9]These predictions were made in 1972 prior to the OPEC embargo and their validity is questionable due to the higher cost of petroleum.

Table IV. Projected Crude Petroleum Imports (million barrels per day)

	1975	1980	1985	2000
NPC[a/]				
Case I	7.0	5.5	3.4	n.a.
Case II	7.2	7.4	8.8	n.a.
Case III	8.5	10.3	13.6	n.a.
Case IV	9.6	15.3	19.3	n.a.
USDI[b/]				
Case I	6.3	8.9	12.9	19.5
Case II	1.6	1.7	1.2	2.4
RRNA[c/]	n.a.	6.9	n.a.	19.7

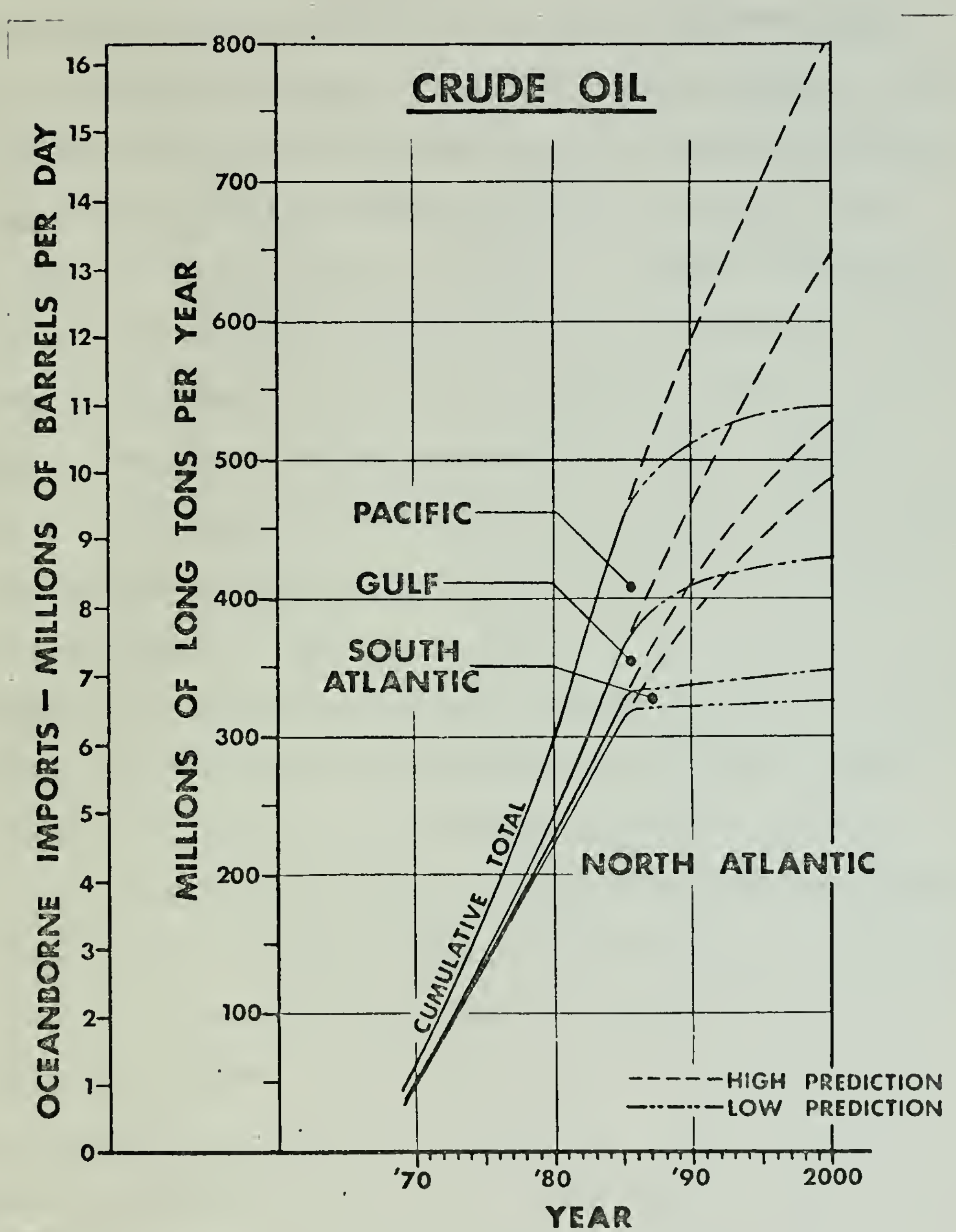
a/ National Petroleum Council (Total imports of crude petroleum)
CASE I - Based on very optimistic assumptions concerning supplies of coal, natural gas, and nuclear energy including resolution of environmental controversies, availability of governmental land for energy resource development, adequate price and tax incentives, and a high degree of success in locating undiscovered resources.
CASE II - Based on less optimistic assumptions regarding energy sources competing with petroleum, but these, nevertheless, are more favorable than factors presently influencing energy supplies.
CASE III- Considered the most likely outcome, is based on the assumption that the present policies will continue.
CASE IV - Based on the assumption that there will be a sharp reduction in the availability of fuels other than petroleum and that the highest level of petroleum imports will be required.

b/ Department of the Interior (Total waterborne crude petroleum imports)
CASE I - No stimulation of U.S. oil and gas production.
CASE II - Maximum stimulation of U.S. oil and gas production.

c/ Robert R. Nathan Associates (Total waterborne imports)

SOURCES: Mobil Oil Corp. - Statement by Dr. D. H. Clewell, Senior Vice President, Mobil Oil Corp. at NOAA "The Oceans and National Economic Development" conference 17 July 1973. (Original Source - National Petroleum Council study - U.S. Energy Outlook, 1971.) U.S. Department of the Interior - statement by J. Horton, Assistant Secretary for Land and Water Resources, Department of the Interior before House Merchant Marine and Fisheries Committee, 12 June 1973. (Original source - Department of the Interior - United States Energy Through Year 2000, Government Printing Office, 1972.) Robert R. Nathan Associates, U.S. Deepwater Port Study, prepared for U.S. Army Corps of Engineers, August 1972.

Drawing 3. Projected Annual Oceanborne Imports of Crude Oil to the Year 2000 (millions of barrels per day and millions of long tons per year)



Source: Soros Associates, Inc. Offshore Terminal System Concepts, prepared for the U.S. Department of Commerce, Maritime Administration, September 1972, Executive Summary, Fig. 1-1.

p. 2] If Project Independence is implemented and does in fact become a reality the various projections in Table IV and Drawing 3 will not be accurate.

Canada and Venezuela have in the past been the major source of the United States' imported crude petroleum. However, the United States has recently been importing progressively greater quantities from countries in Africa, the Middle East and the Far East. Robert R. Nathan Associates recently predicted that by 1980 the United States will be importing approximately 71% of its imported crude oil requirements from these three geographical areas. [Ref 3, Vol. II, p. 73] Approximately 85% of the free world's known crude oil reserves are located in the Middle East, Africa, and Southeast Asia. [Ref. 8, p. 781]

As was the case with non-fuel mineral resources, import-dependence for fuel mineral resources is also to a large extent economic. [Ref 4, p. 45] Vast reserves of coal, natural gas, and petroleum remain either beneath or offshore the United States. However, the accessibility of these fuel resources is progressively declining, and the costs of exploration, development, and exploitation are increasing. Environmental pressure and legislation is also acting as a deterent to expanded fuel resource extraction. Due to economic and environmental considerations the United States will, at least for the near future, remain import-dependent for millions of barrels of crude petroleum per day.

C. CHANGING GEOGRAPHICAL ORIGIN OF IMPORTED MINERAL RESOURCES

For many years the United States has been fortunate to receive the majority of its imported fuel and non-fuel mineral resources from Canada, Latin America, and Caribbean countries. [Ref 4, p. 46] As indicated in Table V, the vast majority of these resources imported by the United States in 1970 originated in the Western Hemisphere. As a result of this fortunate situation, transportation costs for these basic mineral resources were relatively low. However, this situation has been gradually changing as our Western Hemisphere neighbors are becoming more highly industrialized and are, therefore, using a greater share of their mineral resources. The recent trend in the origin of imported mineral resources, as indicated previously, is away from the Western Hemisphere countries and toward Australia, New Zealand, Africa, the Middle East and Southeast Asia. [Ref. 4, p. 46] The trend in the future is expected to be toward longer shipping distances for fuel and non-fuel mineral resource imports. This trend is not unique to the United States, as indicated on Table VI, this trend is occurring throughout the world

D. INCREASING COMPETITION IN THE WORLD MARKET FOR MINERAL RESOURCES

The United States is not the only major industrial country that is becoming progressively more dependent on foreign fuel and non-fuel mineral resources. For example, Japan and Western European countries have, in general, been dependent

Table V. Percentage Distribution of Mineral Imports by Area of Origin, 1970

	North America	South America	Europe	Asia	Africa	Oceania	Soviet Bloc
Bauxite	72	28	-	-	-	-	-
Aluminum Scrap	82	-	15	1	-	-	2
Antimony	18	36	-	-	46	-	-
Chrome Ores	-	-	23	19	15	-	43
Columbium Ores	15	56	6	3	20	-	-
Copper Ores	20	28	-	50	-	2	-
Copper Scrap	92	2	6	-	-	-	-
Fluorspar	69	1	29	-	1	-	-
Iron Ore	62	32	-	-	4	2	-
Iron & Steel Scrap	99	-	1	-	-	-	-
Lead Ore	57	25	-	-	-	18	-
Lead Scrap	97	-	3	-	-	-	-
Manganese	3	34	2	4	53	4	-
Mica	-	29	2	60	9	-	-
Magnesium Scrap	41	-	40	10	7	2	-
Mercury	83	-	17	-	-	-	-
Nickel Scrap	80	-	20	-	-	-	-
Platinum Group	28	4	29	23	7	9	-
Thorium Ores	-	-	-	41	-	59	-
Tine Ores	-	100	-	-	-	-	-
Tin Scrap	92	-	-	2	-	6	-
Titanium Ores	2	-	-	-	7	91	-
Tungsten Ores	95	5	-	-	-	-	-
Zinc Ores	83	13	2	-	1	1	-
Zinc Scrap	100	-	-	-	-	-	-
Zirconium Ores	3	-	5	-	4	88	-
Petroleum Crude	52	28	1	12	7	-	-
Petroleum Products	47	42	9	1	-	-	-
Natural Gas	98	1	-	-	1	-	-

Source: Alexander Lang, "A Crisis in Critical Commodities," Columbia Journal of World Business, Vol. III, Nr. 1, (Spring 1973), p. 46. (Original Source - U.S. Imports, U.S. Department of Commerce, Bureau of Census, FT 135, December 1970.)

Table VI. Average Distances of Oceanborne Cargo Movements in World Trade, by Major Commodity, 1960-1971 (In nautical miles)

Commodity	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971[a]
Major wet bulk												
Crude oil......	--	--	4,508	4,363	4,461	4,493	4,331	5,060	5,465	5,572	5,655	5,774
Major dry bulk												
Iron ore.......	2,614	3,041	3,078	3,252	3,403	3,467	3,758	3,970	4,122	4,294	4,425	4,365
Coal...........	3,152	3,271	3,208	3,156	3,317	3,661	3,705	4,015	4,247	4,639	4,762	4,796
Bauxite/alumina	2,000	2,059	2,666	2,059	2,053	2,190	2,391	2,480	2,692	2,800	2,912	n. a.
Phosphates.....	3,056	3,158	3,050	3,045	3,083	3,400	3,556	3,679	3,719	3,688	3,515	n. a.

a/ Preliminary

Source: Robert R. Nathan Associates, United States Deepwater Port Study, prepared for the U.S. Army Corps of Engineers, Vol. V, p. 12, August 1972.

for years. As their economies continue to expand import requirements will, most likely, continue to increase. The less developed countries, which are a primary source of much of the world's high grade mineral resources, are also expanding their industrial bases and raising their standards of living. Their annual consumption growth rates of mineral resources will, most likely, surpass the rates of many of the industrialized nations. (See Table VII.) Due to the ever increasing world aggregate demand for mineral resources, the world market place for mineral resources is becoming progressively more competitive. The United States, as it continues to become more import-dependent, will be forced to bargain for mineral resources in a highly competitive market place.

Table VII. Annual Growth Rates for Consumption of Major Minerals in Selected Countries, 1964-69 (In percentages)

	USA	France	Italy	W. Germany	U.K.	Japan
Petroleum	5.0	11.1	9.7	11.6	7.6	17.4
Copper	3.0	2.5	3.7	3.4	-	12.0
Lead	5.0	2.9	11.8	5.0	-	3.2
Zinc	2.5	3.3	6.4	-	-	9.5
Nickel	-	9.2	13.8	7.4	-	17.5
Aluminum	7.5	8.0	13.8	10.8	2.0	22.5
Steel	3.3	5.3	11.6	3.9	0.8	14.5
GNP[a]	4.6	5.5	5.4	4.7	2.3	10.9

Note: a. In constant prices.

Source: Alexander Lang, "A Crisis in Critical Commodities," Columbia Journal of World Business, Vol. III, No. 1, (Spring 1973) p. 49. (Original source - Japan's Ministry of International Trade and Industry, "White Paper on Prospect of National Resources Problems in Japan," Trade and Industry of Japan-Economic Reports, No. 167, 1972.)

IV. PRINCIPAL BULK COMMODITY PORTS AND COMMODITY MOVEMENTS

A. EAST COAST OF THE UNITED STATES

The principal bulk commodity ports on the east coast are Portland, Boston, New York, Philadelphia, Paulsboro, Marcus Hook, Baltimore, Hampton Roads, Charleston, Savannah, Jacksonville and Port Everglades. [Ref. 3, Vol. III, p. 21-69] (See Table VIII for depth of water in main channels.) Existing main channel depths vary from a minimum of 35 to a maximum of 45 feet. Thus channel depths limit the maximum size of fully laden bulk carriers to approximately 80,000 DWT.

The major bulk commodity movements through ports in the New England and New York Harbor area are receipts of domestic and foreign crude and petroleum products and domestic coal. The majority of crude petroleum is received at Portland for further delivery to Canadian refineries via pipeline. Since this region has very limited refining capacity most of the petroleum received is in the form of finished products. [Ref. 3, Vol. III, p. 20-21]

The major bulk commodity movements through ports in the Delaware Bay and River area are foreign and domestic crude and petroleum products. However, due to the refining capacity in this area more crude is received than finished products. The port of Philadelphia also receives substantial shipments of iron ore. [Ref. 3, Vol. III, p. 20-21]

Table VIII. Main Channel Depths of Principal Bulk Commodity Ports in the United States

Name of Port	Depth of Main Channel at Mean Low Water (in feet)
Portland	35-45
Boston	40
New York	35-45
Philadelphia	35-40
Paulsboro	35-40
Marcus Hook	35-40
Baltimore	37-42
Hampton Roads	35-45
Charleston	35
Savannah	38
Port Everglades	37
Tampa	34-36
Mobile	40-42
New Orleans	35-40
Beaumont-Port Arthur	36
Galveston-Houston	40-42
Port Lavaca	36
Corpus Christi	35-47
Brownsville	36-38
Long Beach	55-62
Los Angeles	47-50
Richmond	35-45
Portland	48
Tacoma	30-43
Seattle	30-43

Source: Robert R. Nathan Associates, U.S. Deepwater Port Study, Vol. III, prepared for the U.S. Army Corps of Engineers, Institute of Water Resources, August 1972.

In the Chesapeake Bay area the movement of bulk commodities is dominated by exports of coal from the ports of Baltimore and Hampton Roads and the receipt of iron ore at Baltimore. Foreign and domestic crude and petroleum products are also received, primarily at Newport News and Baltimore. [Ref. 3, Vol. III, p. 20-21]

The region between the port of New York and Hampton Roads is very heavily industrialized. In 1970 the ports in

this region handled over 90% of all U.S. coal exports and over 80% and 50% of the total iron ore and crude petroleum imports respectively. During the period between 1970 and 1980 the Maritime Administration has predicted the foreign traffic through these ports will increase by 135% for crude petroleum, 30% for coal, and 22% for iron ore. [Ref. 10, p. 1]

In the south Atlantic ports the major bulk commodity movements are the receipt of foreign and domestic crude and petroleum products and the export of grain and phosphate rock. The receipt of petroleum products is far greater than crude due to the very limited refining capacity in this area. [Ref. 3, Vol. III, p. 68-69]

In 1970 the total demand for petroleum products in the United States was approximately 14.7 MM B/D. The 16 eastern most states which make up Petroleum Administration for Defense District I, (PAD I) consumed approximately 5.85 MM B/D or 40% of all petroleum products consumed in the United States. [Ref. 3, Vol. II, p. 38] PAD I depends heavily on both domestic and foreign sources of finished petroleum products since existing refining capacity can only supply one quarter on the district's demand. In the past, the majority of the crude petroleum supplied to PAD I refineries, was from the Gulf states. However, due to a reduced supply of domestic crude from the Gulf states, more crude has recently been imported. This trend is expected to continue in the future. PAD I refineries are primarily located on coastal

and waterway areas in New York, New Jersey, Pennsylvania and Delaware. Three quarters of the refinery capacity in PAD I is served through the Delaware Bay and River.

B. GULF COAST OF THE UNITED STATES

The principal bulk commodity ports on the Gulf Coast are Tampa, Mobile, New Orleans (and other Mississippi ports). Beaumont-Port Arthur, Galveston-Houston, Port Lavaca, Corpus Christi and Brownsville. [Ref. 3, Vol. III, p. 96-97] (See Table VIII for depth of water in main channels.) Existing main channel depths vary from a minimum of 34 to a maximum of 47 feet. Thus channel depths limit the maximum size of fully laden bulk carriers to approximately 80,000 DWT.

The major bulk commodity movements through ports in western Florida and Alabama are exports of phosphate rock from Tampa and grain from Mobile and the receipt of petroleum products and coal in Tampa and iron ore and bauxite in Mobile. In Louisiana ports the major bulk commodity shipments are grain and petroleum products and the major receipt is bauxite. In the Texas ports the major shipments are limited to grains and petroleum products and the major receipt is bauxite. [Ref. 2, Vol. III, p. 96-97] The Gulf coast states of Louisiana, Texas, and Alabama receive approximately 95% of all bauxite imported by the United States. Tampa exports approximately 80% of all phosphate rock exported by the United States.

The major refining centers on the Gulf coast are located in the Houston, Beaumont, Port Arthur, Corpus Christi, New Orleans, Baton Rouge, Lake Charles and Pascagoula. The Gulf coast states until recently, had been self-sufficient in crude petroleum. However, now more foreign crude is progressively being imported. By 1980 states in the Gulf coast will, most likely, be importing approximately 3 MM B/D. [Ref. 2, Vol. II, p. 49]

C. WEST COAST OF THE UNITED STATES

The principal bulk commodity ports on the west coast are Long Beach, Los Angeles, Richmond, Portland, Tacoma and Seattle. [Ref. 3, Vol. III, p. 144-145] (See Table VIII for depth of water in main channels.) Existing main channel depths vary from a minimum of 30 to a maximum of 62 feet. Ports at Ferndale, Oregon and the California ports of Richmond and Los Angeles can accommodate fully laden bulk carriers up to 100,000 DWT. Long Beach can accommodate fully laden bulk carriers up to 130,000 DWT. There are approximately nineteen offshore tanker terminals on the coast of California. [Ref. 11, p. 723] Most of the terminals consist of conventional buoy moorings with submerged pipelines. However, none of these terminals is considered to be a deepwater facility since the largest tankers that can be accommodated are 130,000 DWT. [Ref. 12, p. 41]

The major bulk commodity movements through ports in California are the receipt of crude and petroleum products and shipment of petroleum products. In the Washington and

Oregon ports the major bulk commodity movements are the export of grains and the receipt of petroleum products and alumina. [Ref 3, Vol. III, p. 144-145]

The domestic production of crude petroleum by west coast states has been declining. California has been the largest producer of crude petroleum of all western states, however production of crude has been declining since 1968. Until completion of the Alaska pipeline, foreign sources of petroleum will, most likely, increase. In 1970 approximately 0.3 MM B/D were imported, by 1980 the Corps of Engineers have predicted that foreign imports for west coast states may reach 2 MM B/D. Ninety five percent of the west coast refining capacity is located in the three major service areas of Puget Sound, San Francisco Bay and Los Angeles-Long Beach. [Ref. 12, p. 21]

V. CONSTRUCTION OF OCEAN BULK CARRIERS

A. RECENT HISTORY IN THE CONSTRUCTION OF OCEAN BULK CARRIERS

During the years immediately following World War II emphasis was placed on rebuilding the world's merchant fleet, however there was little incentive or time for experimentation. During the late 'forties and 'fifties the world's merchant fleet was rebuilt largely along traditional lines. [Ref 13, p. 153] Until 1957 most ocean bulk carriers were limited in size to transit the Suez Canal. However, the growing dependence by many of the world's industrial nations on foreign mineral resources and the closing of the Suez Canal in November of 1957 added new impetus for change in shipbuilding. Even though the Suez Canal was closed for a relatively short duration it was evident to the Northern European countries and to a lesser extent the United States, that the long route from the Persian Gulf oil supply around the coast of Africa was unsatisfactory. Since the shipment of crude petroleum dominated world bulk trade and supplies of petroleum were being placed in jeopardy, tanker construction received top priority.

Without the size limitation of the Suez Canal as a constraint shipbuilders began to build progressively larger tankers. The Japanese shipyards took the lead and in 1959 launched the 114,365 DWT Universe Apollo. During the 1960's, shipyards began to incorporate new technologies. Computer

aided ship design was used to free the naval architect from the past practice of making conservative, incremental design changes. Analytical techniques from the fields of operations research and systems analysis were also introduced to quantitatively define and compare various ship and supporting system designs in order to select the optimal combination. There were also major technological advances in hull design and fabrication, propulsive machinery, cargo handling devices and automatic controls. [Ref. 13, p. 156] As a result of the combined technological improvements, the competitive nature of the industry, and a considerable amount of ingenuity, shipyards produced progressively larger and more efficient bulk cargo ships.

By the end of 1966 there were 23 ocean bulk carriers in service with a capacity over 100,000 DWT. The second closing of the Suez Canal in mid-1967 added further impetus to the construction of more large ocean bulk carriers. During the four years between 1966 and 1970 the number of ships in the world fleet with a capacity in excess of 100,000 DWT increased from 23 to 319. (See Table IX.) Of this number 275 were tankers and 44 were either dry bulk or multi-purpose bulk carriers. In 1970 the largest ships in the worlds fleets were the six 326,000 DWT tankers of the Universe Ireland class. These ships were built in Japan with a length of 1,133 ft., beam of 175 ft. and a draft of 81 ft. Although the size of the dry bulk and the multi-purpose bulk carriers in service in 1970 was considerably less than the

Table IX. Deadweight Distribution of Large Bulk Ships (Over 100,000 DWT) in Operation as of December 31, 1970

Year Built	Total	100,000 124,999	125,000 149,999	150,000 199,999	200,000 249,999	250,000 299,999	300,000 349,999	350,000 and over
1959	2	2	-	-	-	-	-	-
1960	1	1	-	-	-	-	-	-
1962	2	1	1	-	-	-	-	-
1963	2	2	-	-	-	-	-	-
1964	3	3	-	-	-	-	-	-
1965	9	9	-	-	-	-	-	-
1966	23	16	4	2	1	-	-	-
1967	28	21	2	4	1	-	-	-
1968	56	23	5	12	14	-	2	-
1969	81	18	3	15	37	4	4	-
1970	112	19	15	9	58	11	-	-
TOTAL	319	115	30	42	111	15	6	-
Type of Ship								
Bulk Carrier	7	4	1	2	-	-	-	-
Bulk/Oil	5	-	2	3	-	-	-	-
Ore/Carrier	10	10	-	-	-	-	-	-
Ore/Oil	17	11	5	1	-	-	-	-
Ore/Bulk/Oil	5	3	1	1	-	-	-	-
Tanker	275	87	21	35	111	15	6	-
TOTAL	319	115	30	42	111	15	6	-

Source: U.S. Department of Commerce, Maritime Administration. The Economics of Deepwater Terminals, p. 5, Government Printing Office, 1972.

Universe Ireland tankers there were seven ships of this type in the 150,000 to 199,999 DWT range. During the period 1966 to 1970 the number of ocean bulk carriers in operation over 100,000 DWT increased at an average annual rate of 350 percent. [Ref. 10, p. 6]

At the end of 1970, as shown on Table X, there were, in the over 100,000 DWT class, 279 tankers under construction or on order averaging 240,000 DWT and 181 dry and multipurpose bulk carriers averaging 150,000 DWT. The growth of large ocean bulk carriers exceeding 100,000 DWT placed under construction or on order was phenomenal. In 1971 a new, larger tanker joined the world fleet. The 372,400 DWT Nesseki Maru, also built in Japan, had a length of 1,243 ft., beam of 177 ft. and a draft of 89 ft. [Ref. 10, p. 7] In 1972 the 477,000 DWT tanker Globtik Tokyo was launched in Japan and became the largest ship in the world, with a length of 1,243 ft., beam of 203 ft. and draft of 92 ft. In 1973 the Globtik London was launched, she is of the same dimensions as her sister ship, the Globtik Tokyo. The Globtik London and Globtik Tokyo are presently the largest ships afloat and each has the capacity of almost 3.5 million barrels of crude petroleum. The world's largest multi-purpose bulk carrier is the 280,000 DWT Svealand built in Sweden and launched in 1973. The Svealand has a length of 1109 ft., beam of 179 ft. and draft of 71 ft. [Ref. 14, p. 121] During the past few years the majority of tankers that have joined the fleet with a capacity of over 100,000 DWT have been in the 200,000 to 300,000 DWT range. (See Table XI.)

Table X. Deadweight Distribution of Large Bulk Ships (Over 100,000 DWT) Under Construction or on Order as of December 31, 1970

Type of Ship	Total	100,000 124,999	125,000 149,999	150,000 199,999	200,000 249,999	250,000 299,999	300,000 349,999	350,000 and over
Bulk Carrier	44	34	7	3	-	-	-	-
Ore Carrier	4	2	1	1	-	-	-	-
Ore/Oil	62	1	16	11	22	12	-	-
Ore/Bulk/Oil	71	33	5	33	-	-	-	-
Tankers	279	13	20	7	106	123	9	1
TOTAL	460	83	49	55	128	135	9	1

Source: U.S. Department of Commerce, Maritime Administration, The Economics of Deepwater Terminals, p. 7, Government Printing Office, 1972.

Table XI. World Tanker Fleet: Size Analysis

Size Groups (DWT)	No. of Existing Tankers Jan. 1971	No. of Existing Tankers Jan. 1973
100,000 - 149,999	108	136
150,000 - 199,999	35	38
200,000 - 249,999	111	204
250,000 - 299,999	15	58
300,000 - 349,999	6	7
350,000 - 399,999		1
400,000 and over		1
TOTAL	275	445

Sources: Ocean Industry, June 1973 and The Economics of Deepwater Terminals, U.S. Department of Commerce, Maritime Administration, Government Printing Office, 1972.

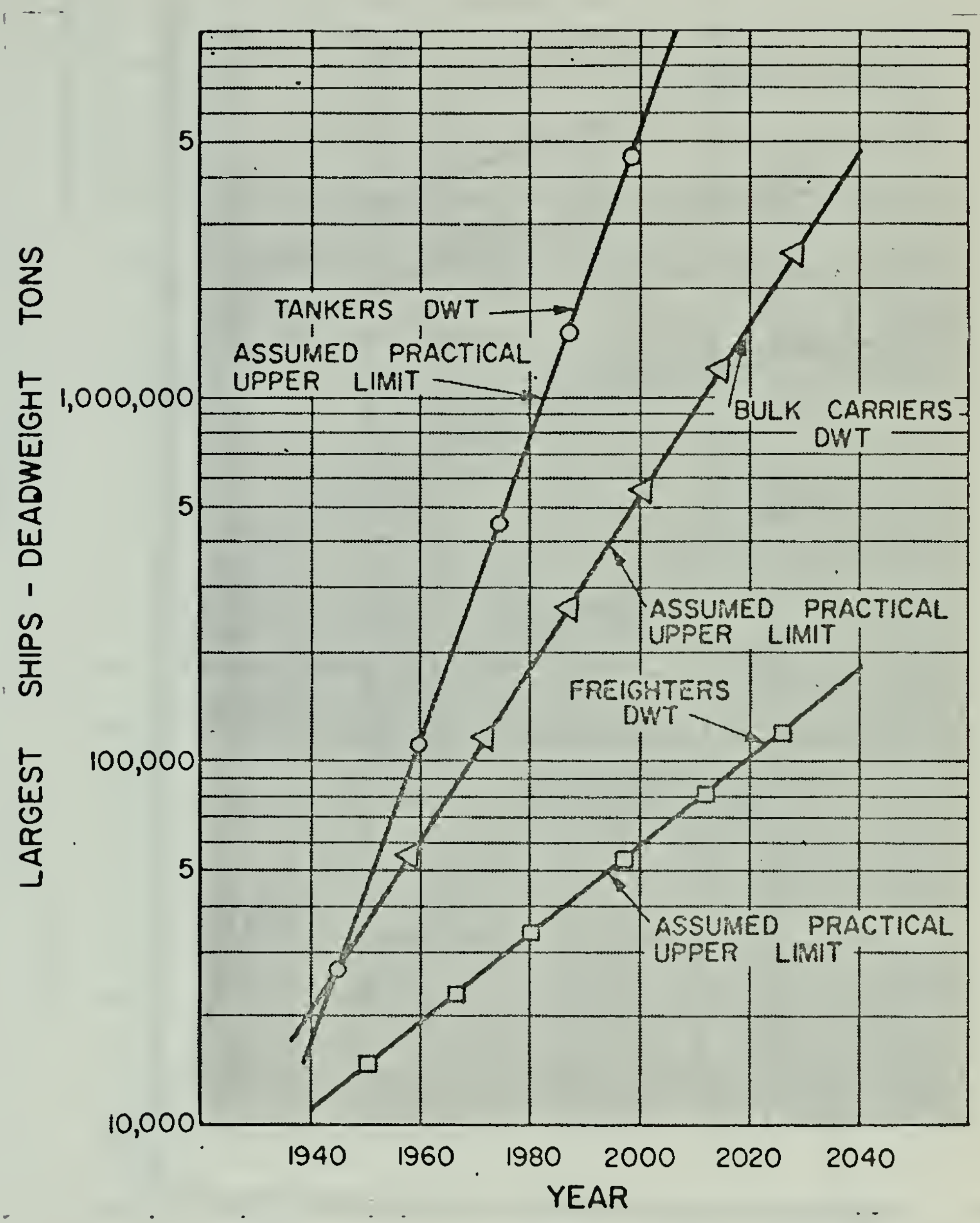
United States shipyards have only recently begun constructing tankers with capacities over 200,000 DWT. The Seatrain Shipbuilding Corporation recently launched the 225,000 DWT Brooklyn. This is the largest ship ever launched in the United States, it is 1094 ft. long and has the capacity to carry 1.5 million barrels of crude petroleum. The Seatrain yard, located at the old Brooklyn Navy Yard is also constructing two additional tankers of the same class. Bethlehem Steel Corporation's Sparrow's Point Yard is presently building three 265,000 DWT tankers. The estimated completion date for the first tanker is May 1975. The United States Government will pay an estimated $19 to $30.5 million dollars in construction differential subsidies for each of these six VLCCs, [Ref. 15, p. 9] however, their full load draft precludes their entry into any U.S. port.

B. FUTURE TRENDS IN THE CONSTRUCTION OF OCEAN BULK CARRIERS

The size of the ocean bulk carriers presently on order indicates that even larger ships will soon be joining merchant fleets. Shell Oil Company has recently contracted for the construction of two tankers in France, each with a deadweight tonnage of 533,000. Globik, the British-based shipping group recently placed an order for a 706,000 DWT tanker with IHI - Ishikawajima Heavy Industries of Japan. Drawing 4 shows the size of the largest tankers, bulk carriers and freighters up to the year 2040 as projected by the U.S. Department of Commerce, Maritime Administration. The numbers indicated contain arbitrarily-chosen practical limits of ships based upon an assessment of the current and potential state-of-the-art. The limit of ship sizes indicated shows the possibility of a 1,000,000 DWT tanker by 1982 and a 400,000 DWT bulk carrier by 1995.

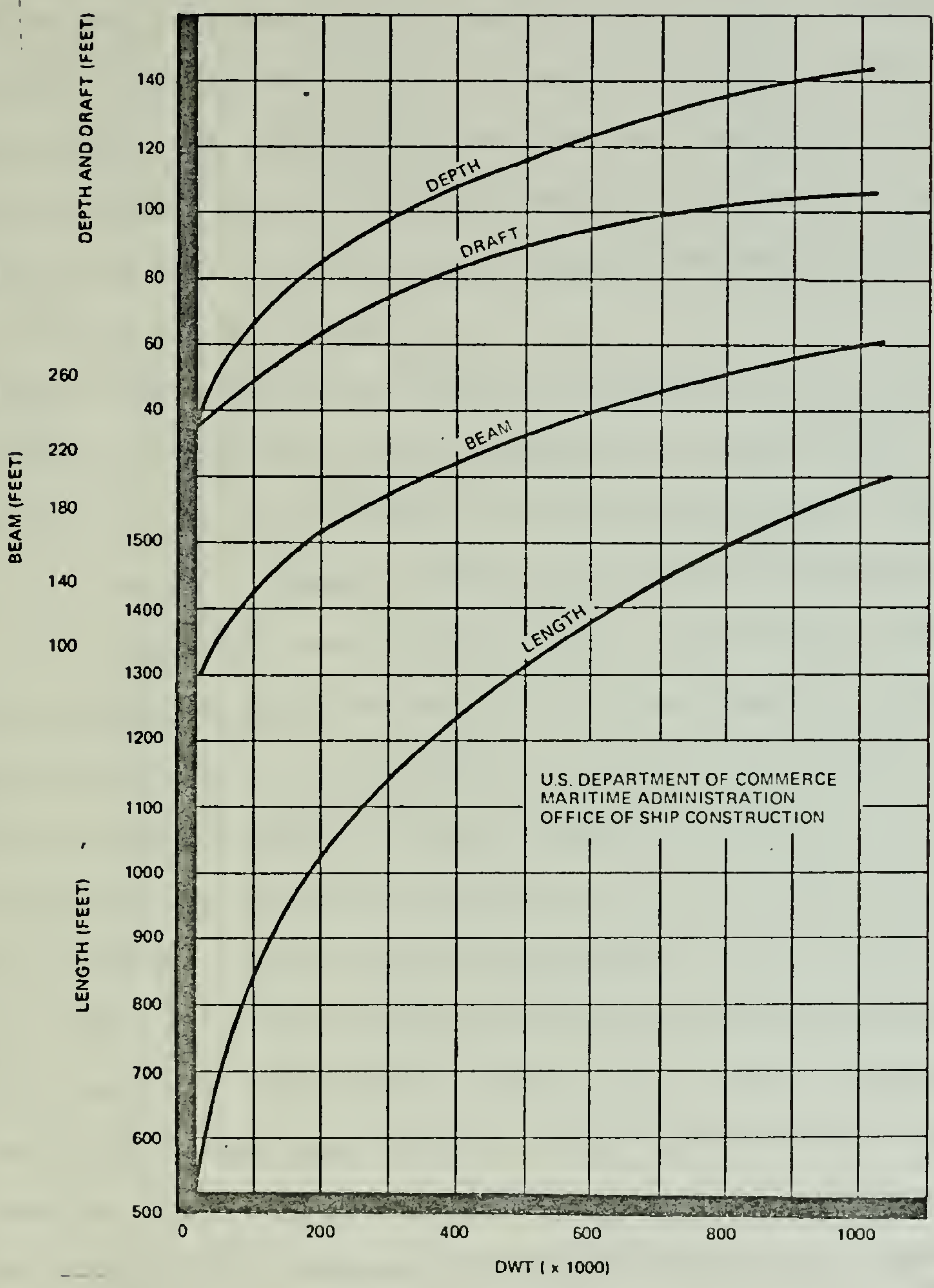
There is little doubt in the shipbuilding industry that a 1,000,000 DWT tanker is a physical possibility within the next few years. The Onassis group is presently designing a million ton tanker. A great deal of discussion has recently taken place concerning the proposed million ton tanker. One disadvantage of such a mammoth tanker is its draft, which will be over 100 ft. (See Drawing 5.) Due to a deeper draft some of the existing trade routes would become obsolete. For example, a million ton tanker could not enter the North Sea via the English channel. IHI, which has built the majority of the largest tankers presently afloat, claims that a million ton tanker would not be economically efficient.

Drawing 4. Projected Deadweight Tonnage of Large Ships to the Year 2040



Source: Casimer J. Kray, "Supership Effect on Waterway Depth and Alignment," Journal of Waterways and Harbours Division, Proceedings of the American Society of Civil Engineers, (May 1970), p. 498. (Original source - U.S. Department of Commerce, Maritime Admisistration.)

Drawing 5. Tanker Characteristics.



Source: Soros Associates, Inc. Offshore Terminal System Concepts, prepared for the U.S. Department of Commerce, Maritime Administration, September 1972, Part I, Fig. 1-34.

The construction price per deadweight ton is presently at a minimum between 600,000 and 700,000 DWT. Any ship that is constructed over 800,000 DWT would, most likely, require twin screws. Due to the loss of economy with twin screws, IHI claims that the transportation cost per long ton for a million ton tanker would be approximately equal to the transportation cost per long ton of a single screw 400,000 DWT tanker. [Ref. 16, p. 27-28]

Although there are a few tankers presently on order above 500,000 DWT, the majority of the tankers on order above 100,000 DWT are in the 250,000 to 300,000 DWT range. (See Table XII.) As of 1 January 1973 there were 444 tankers on order with a capacity over 100,000 DWT. The Maritime Administration indicates that the majority of new tankers to join the world fleet will, most likely, be under 300,000 DWT. Tankers constructed with a larger capacity would only be able to operate on specific routes between the Middle East, Europe and Japan. These larger ships will, most likely, be severely limited to a few specialized ports having deepwater berthing, handling and storage facilities. The Maritime Administration believes most of the world's tankers will require much more operational flexibility and the spiraling trend to ever larger tankers will level off in the future and stabilize in the 200,000 to 300,000 DWT range. [Ref. 10, p. 6] The Maritime Administration expects a similar leveling off in the construction of both dry and multi-purpose bulk carriers. By 1975 the average size of all dry and

Table XII. Tankers over 100,000 DWT on Order, January 1973

Size Groups (DWT)	On Order
100,000 - 149,999	87
150,000 - 199,999	12
200,000 - 249,999	98
250,000 - 299,999	188
300,000 - 349,999	37
350,000 - 399,999	16
400,000 and over	6
TOTAL	444

Source: Ocean Industry, October 1973, p. 35.

multi-purpose bulk carriers in service is expected to exceed 150,000 DWT and by 1980 the majority of new bulk carriers are expected to be within the 200,000 to 300,000 DWT range. [Ref. 10, p. 7]

Many United States shipyards are presently expanding to construct larger ocean bulk carriers. Avondale and Sun Ship are presently expanding to be able to construct 400,000 DWT ships and Newport News is expanding to construct 600,000 DWT ships. [Ref. 17, p. 31] Todd Shipyards has recently received contracts for six 380,000 DWT tankers and Exxon has recently submitted a subsidy application to the Maritime Administration to construct two 400,000 DWT tankers. In September of 1973 the Maritime Administration held subsidy applications for 35 tankers exceeding 200,000 DWT. [Ref. 18, p. 31]

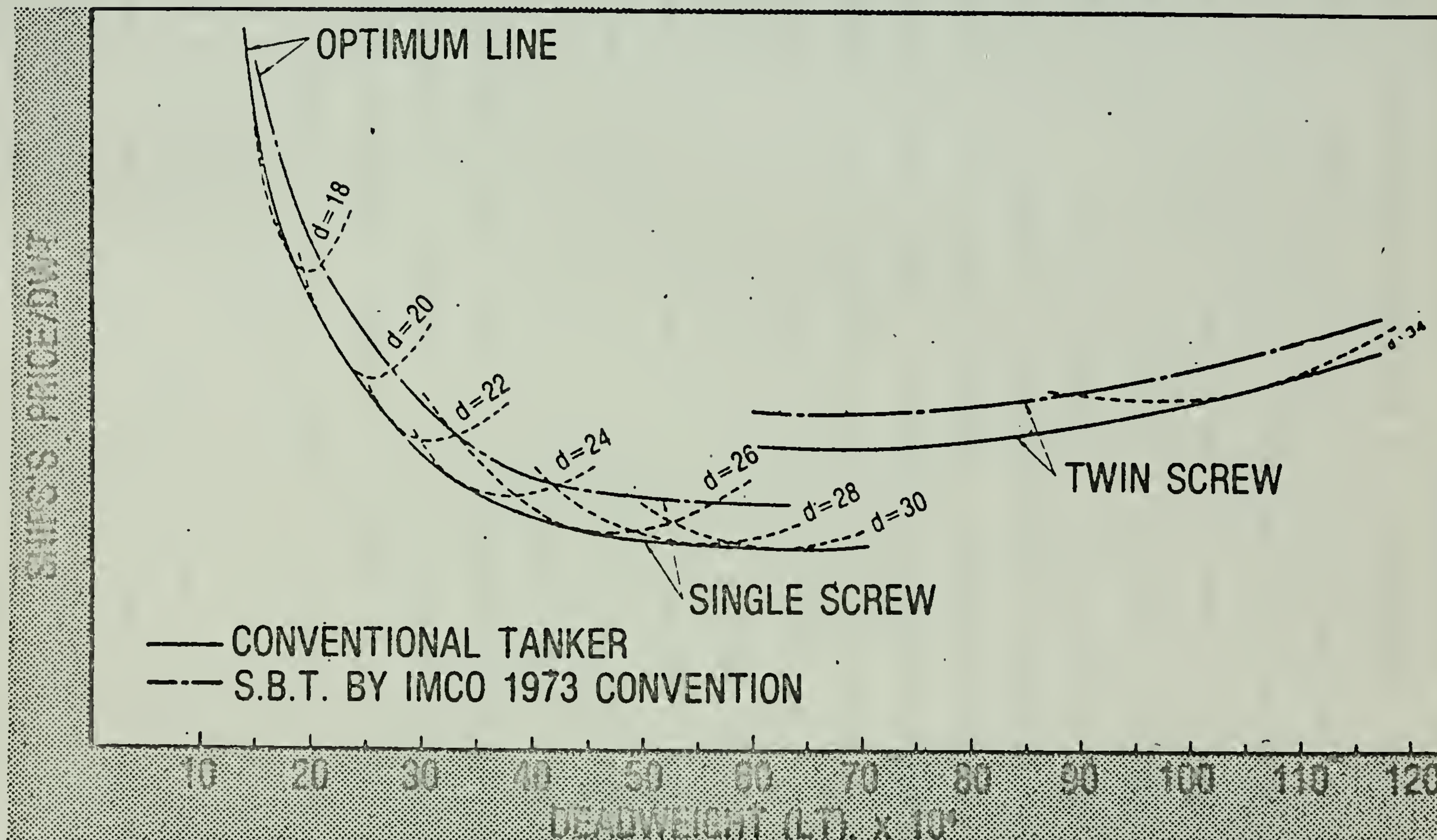
VI. ECONOMICS OF "SUPER" BULK CARRIERS

A. ECONOMIES OF "SUPER" BULK CARRIER CONSTRUCTION

The first analysis of economies of "super" bulk carrier construction is based on a tanker price study conducted by Ishikawajima-Harima Heavy Industries (IHI). IHI is located in Japan and holds the world's record for constructing the largest ships afloat, the 477,000 DWT Globtik London and Globtik Tokyo. Due to the proprietary nature of tanker price information, IHI did not reveal actual prices.

One of the most influential factors in determining a tankers price is the hull steel weight. (Hull steel weight is not to be confused with DWT which is a measure of ships capacity.) Hull steel weight per DWT decreases as ship capacity increases up to approximately 250,000 DWT. Above this point, due to structual considerations, hull steel weight per DWT increases. Therefore, considering hull steel weight alone, above 250,000 DWT tanker price increases per DWT. However, as indicated on Drawing 6, due to other economies in construction, tanker price per DWT continues to decrease beyond 250,000 DWT and does not reach a minimum until approximately 600,000 to 700,000 DWT. Above 700,000 DWT tanker price per DWT increases. From a technical point of view, IHI considers twin propeller propulsion necessary when ship capacity reaches 800,000 DWT. This price rise is represented on the drawing by a break in the cost curve. [Ref. 16, p. 27.]

Drawing 6. Analysis of Trends in Tanker Construction Cost (per DWT)



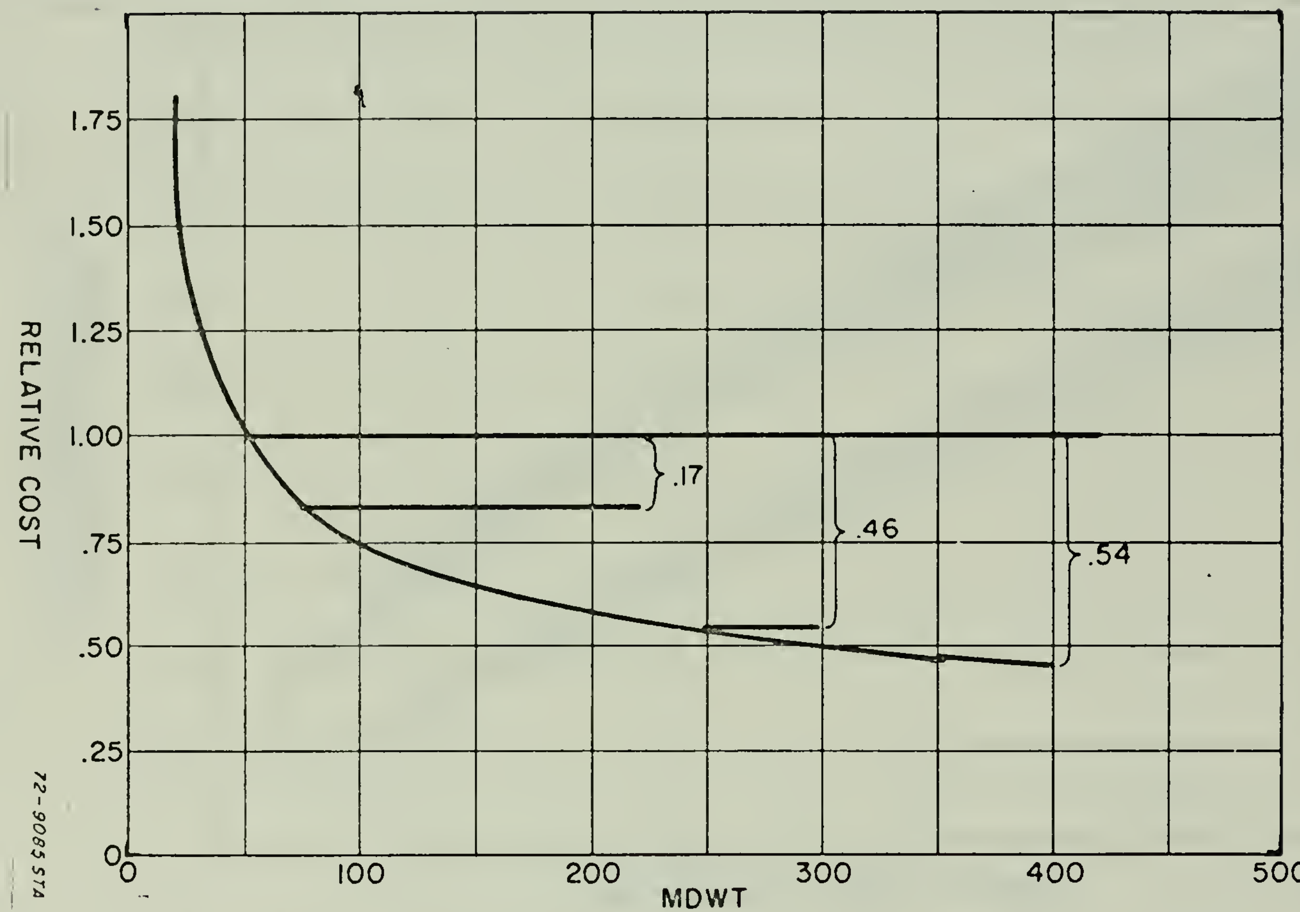
Note: S.B.T. - segregated ballast tanks (required on all new construction over 80,000 DWT after 1980 as per Intergovernmental Maritime Consultive Organization Convention
d - draft in meters

Source: Dr. Tsunco Kuniyasa, "Are Million-Ton Tankers Practical?" Ocean Industry, Vol. 9, No. 3, (March 1974), p. 27.

The second analysis of economies in construction is based on a cost study conducted by Standard Oil Corporation of New Jersey. The analysis uses the base case method and therefore all costs are relative. The costs are based on 1974 delivery costs for tankers constructed in Europe and Japan. A 50,000 DWT tanker is the base and is assigned a relative cost per DWT of one. (See Drawing 7.) The relative cost curve is plotted in terms of relative tanker investment cost per DWT on the vertical axis and ship carrying capacity in DWT on the horizontal axis. As indicated on the drawing, tankers smaller than 50,000 DWT have a higher per DWT cost and tankers larger have a relatively lower per DWT cost. A 250,000 DWT tanker has a relative cost of .54 per DWT and a 400,000 DWT tanker has a relative cost of .46 per DWT. Although significant construction cost economies are demonstrated by this brief analysis even greated economies may be possible. Costs for tankers above 250,000 DWT delivered in 1974 were considered to be excessive due to the unusually high demand and limited shipyard facilities. [Ref. 19, p. 16]

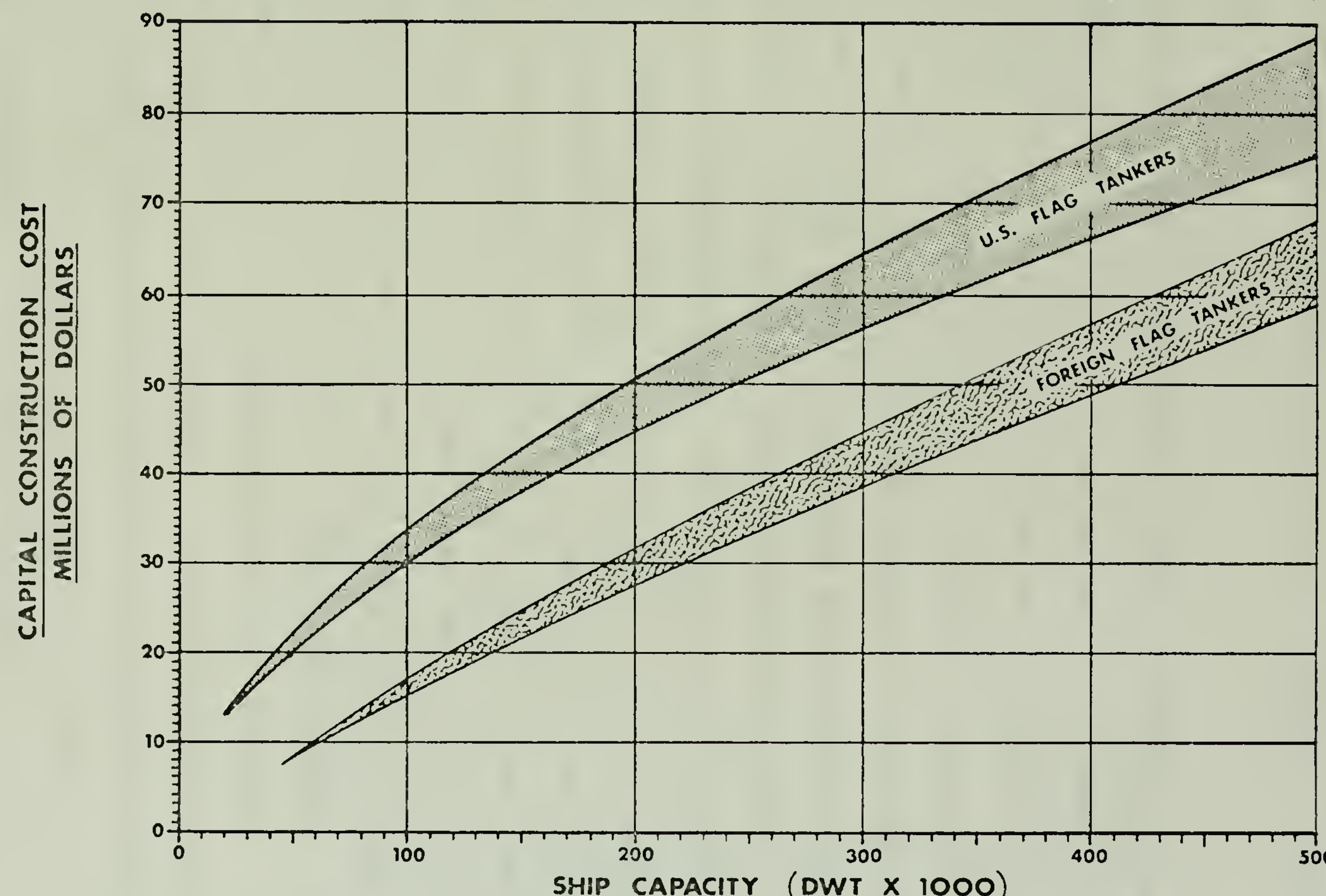
A study conducted by Soros Associates, is supportive of the first two analyses. Drawing 8 summarizes the results of the foreign and U.S. tanker construction cost study. The slope of the total cost curves for both foreign and U.S. flag tankers is decreasing which indicates a decreasing total cost per DWT as ship capacity increases. Soros Associates also conducted a study of construction costs for dry and multi-purpose bulk carriers. The results of this study is

Drawing 7. Relative Tanker Investment Cost.



Source: Christopher J. Carven, "Petroleum Transportation Economics," Mammoth Tankers, Deepwater Ports, and the Environment, printed proceedings of May 18, 1972 meeting sponsored by the Eastern Region of the Maritime Administration and the Propeller Club of the Port of New York, p. 21.

Drawing 8. Capital Construction Cost of U.S. and Foreign-Flag Tankers (1972 dollars)



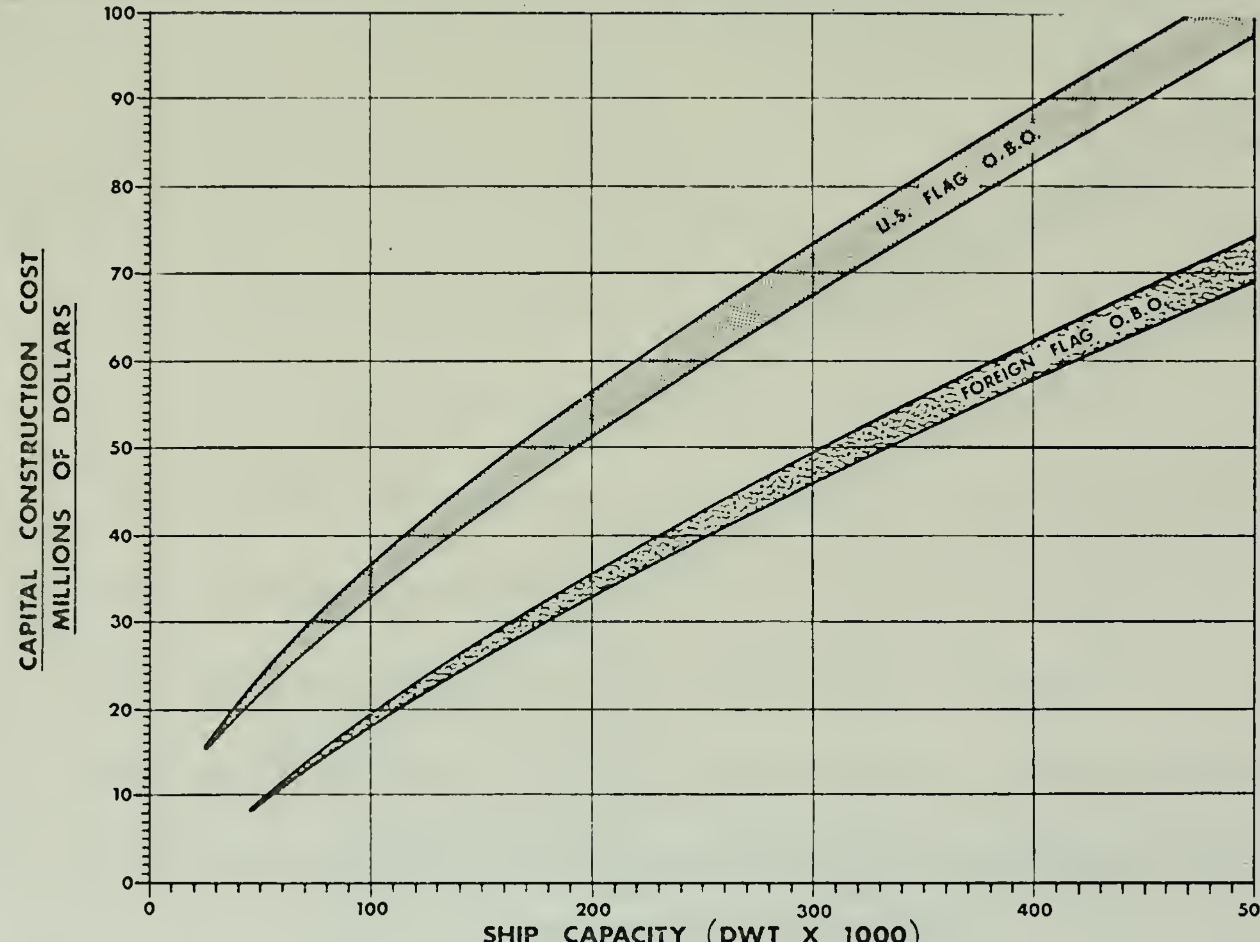
Source: Soros Associates, Inc., Offshore Terminal System Concepts, prepared for the U.S. Department of Commerce, Maritime Administration, September 1972, Part I, Fig. 1-26.

summarized on Drawings 9 and 10. Again, a decreasing slope on the total cost curves indicates a decreasing total cost per DWT as ship capacity increases. [Ref. 20, Part I, p. II-1]

B. ECONOMIES OF "SUPER" BULK CARRIER TRANSPORTATION

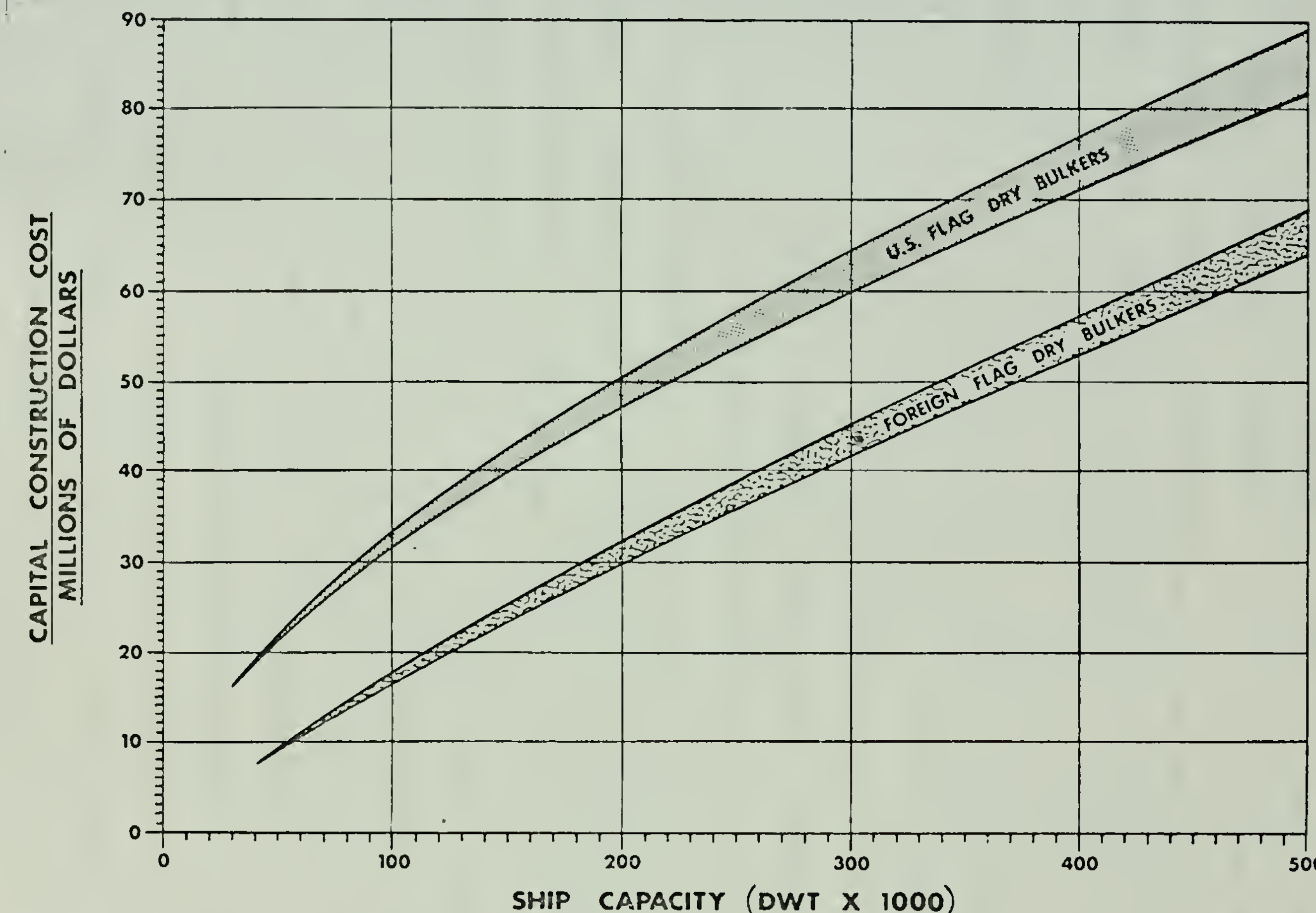
The first analysis of transportation economies available by "super" bulk carriers is based on information from a study conducted by Robert R. Nathan Associates and Hydronautics, Inc. The study was based predominately on foreign flag vessels and transportation costs were generated via parametric programming to a general order of magnitude level. Costs derived do exclude loading, unloading or any other terminal costs, however, costs for inport time were included. All costs were based on 1970 dollars and tanker costs were based upon standard tankers, i.e., they did not have double bottoms or fully clean ballast systems. Anticiapted Intergovernmental Maritime Consultive Organization (IMCO) standards which limit the size of tanks were included. The following simplifying assumptions were also made: single-screw propulsion for all ships, 345 day service year, 39.5 hour average port time, 16 knot service speed, 50 percent load factor (full cargo in one direction and ballast in return) and 26 men on all vessels thru 200,000 DWT with progressive increments to a 50 man crew on a 500,000 DWT tanker. [Ref. 3, Vol. V, p. 111-123]

Drawing 9. Capital Construction Cost of U.S. and Foreign-Flag OBOs (1972 Dollars)



Source: Soros Associates, Inc. Offshore Terminal System Concepts, prepared for the U.S. Department of Commerce, Maritime Administration, September 1972, Part I, Fig. 1-27.

Drawing 10. Capital Construction Cost of U.S. and Foreign-Flag Dry Bulkers (1972 Dollars)



Source: Soros Associates, Inc. Offshore Terminal System Concepts, prepared for the U.S. Department of Commerce, Maritime Administration, September 1972, Part I, Fig. 1-28.

The annual capital charge was 11.746 percent and was applied to all estimates of original capital cost. (The 11.746 figure was composed of a 10 percent return on capital for 20 years which requires a depreciation allowance of 1.746 percent annually based on a sinking fund approach.) No provision was made for income tax or annual capital charges. These costs were considered to be transfer payments and not real economic costs. (Taxes paid by most foreign flag operators would, most likely, be relatively small.) [Ref. 3, Vol. V, p. 111-145] Tables XIII and XIV summarize the results of the Nathan Associates and Hydronautics Inc. parametric computer cost study. Table XIII is presented on an estimated unit cost per cargo ton basis for given ship characteristics and various one way voyage distances. Table XIV was derived from data in Table XIII and is presented on an estimated unit cost per ton mile basis for given ship characteristics and various one way voyage distances. Table XIV is the most beneficial when analyzing transport cost economies. As indicated on the table there are three dimensions to the economies. One economy is realized for a given voyage distance if tanker size is increased. A second economy is realized for a given ship as voyage distance increases, i.e., the transportation cost per ton mile decreases. A third economy occurs with an increase in draft for a given DWT and distance.

Tables XV, XVI and XVII summarize a more detailed study conducted by Nathan Associates. These tables provide a

Table XIII. Estimated Unit Costs Per Cargo-Ton, by Foreign-Flag Vessel Size and Distance (In 1970 dollars)

Vessel draft and d.w.t.	One-way trip distances (nautical miles)					
	1,000	2,000	5,000	7,500	10,000	15,000
<u>35-foot draft</u>						
30,000........	1.079	1.808	4.040	5.948	7.890	12.000
40,000........	.909	1.518	3.385	4.988	6.610	10.005
50,000........	.806	1.356	3.020	4.433	5.910	8.925
51,500........	.798	1.340	2.985	4.380	5.800	8.790
<u>40-foot draft</u>						
45,000........	.848	1.416	3.165	4.658	6.190	9.375
60,000........	.717	1.206	2.680	3.953	5.250	7.890
75,000........	.654	1.096	2.435	3.593	4.750	7.200
78,500........	.638	1.076	2.395	3.518	4.650	7.035
<u>45-foot draft</u>						
65,000........	.685	1.156	2.595	3.810	5.060	7.635
80,000........	.618	1.044	2.320	3.413	4.520	6.810
95,000........	.576	.980	2.180	3.203	4.230	6.360
110,000........	.547	.914	2.055	3.015	4.000	6.015
<u>50-foot draft</u>						
90,000........	.571	.970	2.160	3.180	4.200	6.315
120,000........	.515	.870	1.935	2.835	3.760	5.640
140,000........	.500	.840	1.875	2.745	3.620	5.460
157,000........	.489	.828	1.835	2.700	3.570	5.385
<u>55-foot draft</u>						
120,000........	.500	.842	1.870	2.738	3.610	5.445
140,000........	.479	.818	1.830	2.678	3.540	5.325
180,000........	.470	.796	1.780	2.618	3.460	5.205
210,000........	.462	.784	1.750	2.573	3.410	5.130
<u>60-foot draft</u>						
150,000........	.462	.770	1.715	2.498	3.310	4.950
200,000........	.445	.760	1.690	2.475	3.290	4.935
263,000........	.448	.764	1.695	2.475	3.290	4.935
<u>58½-foot draft</u>						
250,000........	.454	.760	1.685	2.468	3.270	4.905
<u>65-foot draft</u>						
250,000........	.454	.760	1.680	2.460	3.270	4.905
<u>62-foot draft</u>						
300,000........	.446	.746	1.655	2.423	3.200	4.770
<u>71-foot draft</u>						
300,000........	.417	.692	1.530	2.235	2.950	4.425
<u>68½-foot draft</u>						
400,000........	.430	.716	1.575	2.310	3.050	4.560

continued -----

Table XIII. (Continued)

Vessel draft and d.w.t.	One-way trip distances (nautical miles)					
	1,000	2,000	5,000	7,500	10,000	15,000
83-foot draft 400,000........	.388	.654	1.440	2.108	2.790	4.170
75-foot draft 500,000	.432	.718	1.580	2.318	3.050	4.560
95-foot draft 500,000	.386	.644	1.420	2.078	2.740	4.080

Source: Robert R. Nathan Associates, U.S. Deepwater Port Study, prepared for U.S. Army Corps of Engineers, Institute of Water Resources, 1972, Vol. V, p. 124-125.

Table XIV. Estimated Unit Shipping Costs Per Ton-Mile, by Foreign-Flag Vessel Size and Distance

(In 1970 mills)

Vessel draft and d.w.t.	1,000	2,000	5,000	7,500	10,000	15,000
	One-way trip distances (nautical miles)					
35-foot draft						
30,000.......	1.079	.904	.808	.793	.789	.800
40,000.......	.909	.759	.677	.665	.661	.667
50,000.......	.806	.678	.604	.591	.591	.595
51,500.......	.798	.670	.397	.584	.580	.586
40-foot draft						
45,000.......	.848	.708	.633	.621	.619	.625
60,000.......	.717	.603	.536	.527	.525	.526
75,000.......	.654	.548	.487	.479	.475	.480
78,500.......	.638	.538	.479	.469	.465	.469
45-foot draft						
65,000.......	.685	.578	.519	.508	.506	.509
80,000.......	.618	.522	.464	.455	.452	.454
95,000.......	.576	.490	.436	.427	.423	.424
110,000.......	.547	.457	.411	.402	.400	.401
50-foot draft						
90,000.......	.571	.485	.432	.424	.420	.421
120,000.......	.515	.435	.387	.378	.376	.376
140,000.......	.500	.420	.375	.366	.362	.364
157,000.......	.489	.414	.367	.360	.357	.359
55-foot draft						
120,000.......	.500	.421	.374	.365	.362	.363
140,000.......	.479	.409	.366	.357	.354	.355
180,000.......	.470	.398	.356	.349	.346	.347
210,000.......	.462	.392	.350	.343	.341	.342
60-foot draft						
150,000.......	.462	.385	.343	.333	.331	.330
200,000.......	.445	.380	.338	.330	.329	.329
263,000.......	.448	.382	.339	.330	.329	.329
58½-foot draft						
250,000.......	.454	.380	.337	.329	.327	.327
65-foot draft						
250,000.......	.454	.380	.336	.328	.327	.327
62-foot draft						
300,000.......	.446	.373	.331	.323	.320	.318
71-foot draft						
300,000.......	.417	.346	.306	.298	.295	.295
68½-foot draft						
400,000.......	.430	.358	.315	.308	.305	.304

continued-----

Table XIV. (Continued)

Vessel draft and d.w.t.	One-way trip distances (nautical miles) 1,000	2,000	5,000	7,500	10,000	15,000
<u>83-foot draft</u> 400,000.......	.388	.327	.288	.281	.279	.278
<u>75-foot draft</u> 500,000.......	.432	.359	.316	.309	.305	.304
<u>95-foot draft</u> 500,000.......	.386	.322	.284	.277	.274	.272

Source: Robert R. Nathan Associates, U.S. Deepwater Port Study, prepared for U.S. Army Corps of Engineers, Institute of Water Resources, 1972, Vol. V, p. 126-127.

Table XV. Estimated Annual Ocean Shipping Costs for Three Sizes of Foreign-Flag Tankers, by Cost Category

(In thousands of 1970 dollars)

Cost Component	Vessel d.w.t. 40,000[a/]	120,000[b/]	300,000[c/]
Investment	739.4	1,286.1	2,409.4
Operating:			
Crew	169.0	169.0	221.0
Stores and supplies	50.6	87.4	169.1
Subsistence	17.9	17.9	23.5
Maintenance, repair	70.2	104.3	178.3
H&M insurance	78.3	188.2	574.2
P&I insurance	37.6	68.3	141.0
Subtotal	423.6	635.1	1,307.1
Overhead	25.0	25.0	25.0
Total annual cost excluding fuel	1,188.0	1,946.2	3,741.5
Annual fuel costs, 5,000 mile, 1-way trips	351.4	729.8	1,583.1
Total annual cost	1,539.4	2,676.0	5,324.6

a/ 35' draft; length, B.P. 650'; breadth, mld. 97'2"; depth, mld. 47'; SHP, 14,100; speed, 16 knots; crew, 26.
b/ 50' draft; length, B.P. 900'; breadth, mld. 136'; depth, mld. 65'4"; SHP, 28,100; speed, 16 knots; crew 26.
c/ 71' draft; length, B.P. 1,095'; breadth, mld. 190'; depth, mld. 91'; SHP, 58,000; speed, 16 knots; crew, 34.

Source: Robert R. Nathan Associates, U.S. Deepwater Port Study, prepared for U.S. Army Corps of Engineers, Institute of Water Resources, 1972, Vol. V, p. 130.

Table XVI. Estimated Distribution of Annual Ocean Shipping Costs for Three Sizes of Foreign-Flag Tankers, by Cost Category

(In percent)

Cost component	Vessel d.w.t. 40,000 (35' draft)	120,000 (50' draft)	300,000 (71' draft)
Investment..........	48.0	48.1	45.3
Operating:			
Crew................	11.0	6.3	4.2
Stores and supplies..........	3.3	3.3	3.2
Subsistence........	1.2	0.7	0.4
Maintenance, repair............	4.6	3.9	3.3
H&M insurance......	5.1	7.0	10.8
P&I insurance......	2.4	2.6	2.6
Subtotal..........	27.5	23.7	24.5
Overhead............	1.6	0.9	0.5
Total annual cost excluding fuel.....	77.2	72.7	70.3
Annual fuel costs-5,000-mile, one-way trips..........	22.8	27.3	29.7
Total annual cost...............	100.0	100.0	100.0

Source: Robert R. Nathan Associates, U.S. Deepwater Port Study, prepared for U.S. Army Corps of Engineers, Institute of Water Resources, 1972, Vol. V, p. 131.

Table XVII. Estimated Annual Ocean Shipping Costs Per Deadweight Ton for Three Sizes of Foreign-Flag Tankers

(In 1970 dollars)

Cost component	Vessel d.w.t. 40,000 (35' draft)	120,000 (50' draft)	300,000 (71' draft)
Investment..........	18.49	10.72	8.03
Operating:			
Crew................	4.23	1.41	0.74
Stores and supplies..........	1.27	0.73	0.56
Subsistence........	0.45	0.15	0.08
Maintenance, repair............	1.76	0.87	0.59
H&M insurance......	1.96	1.57	1.91
P&I insurance......	0.94	0.57	0.47
Subtotal...........	10.59	5.29	4.36
Overhead............	0.63	0.21	0.08
Total annual cost excluding fuel.....	29.70	16.22	12.47
Annual fuel costs, 5,000 mile, one-way trips..........	8.79	6.08	5.28
Total annual cost...	38.49	22.30	17.75

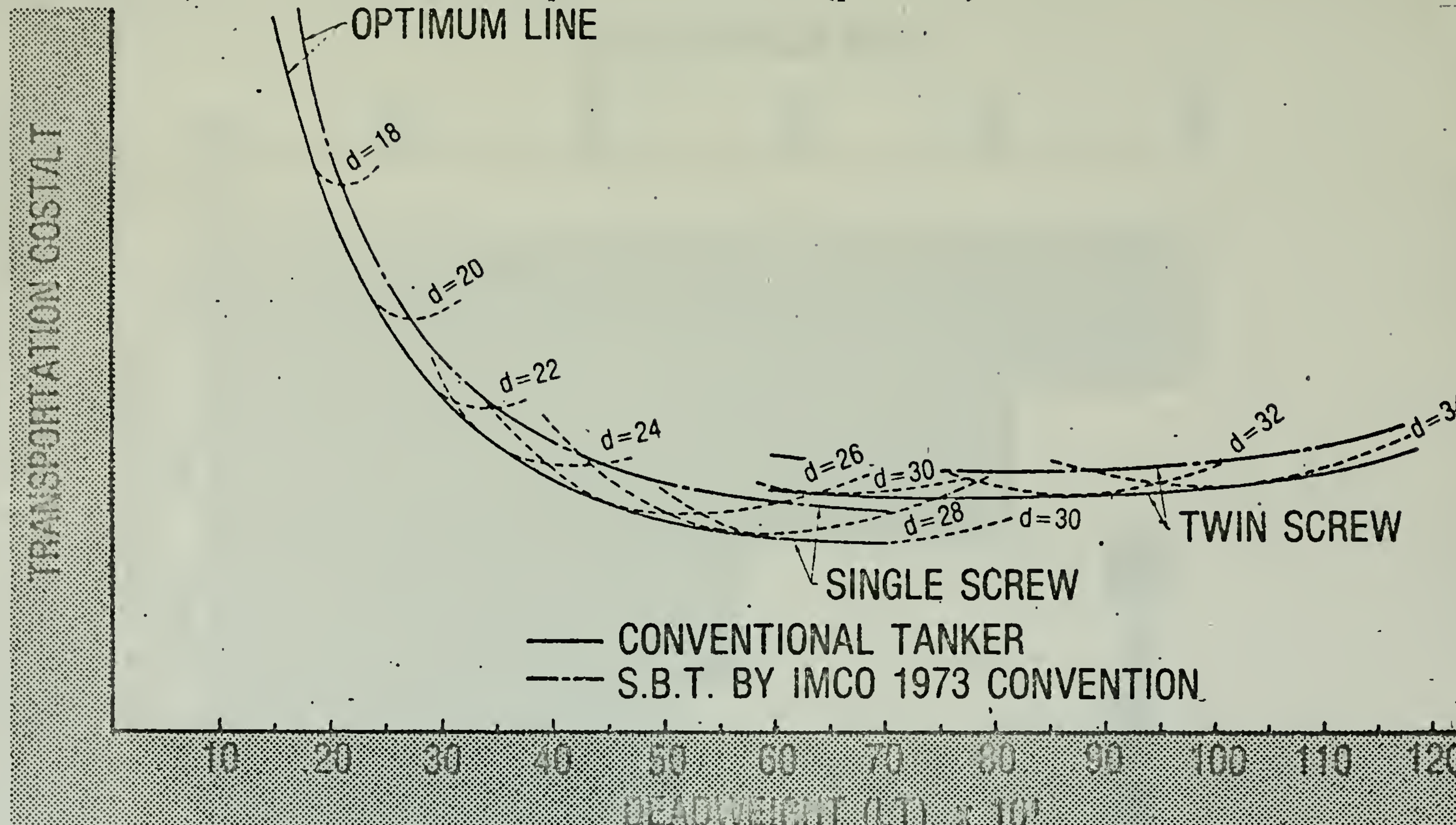
Source: Robert R. Nathan Associates, U.S. Deepwater Port Study, prepared for U.S. Army Corps of Engineers, Institute of Water Resources, 1972, Vol. V, p. 132.

detailed breakdown of the various cost components for three different size tankers. (40,000; 120,000; and 300,000 DWT.) A one-way voyage distance of 5,000 nautical miles was used in computing transportation costs. All previously noted assumptions for the first Nathan Associates study are applicable. Table XV provides an estimated annual component and total shipping cost for the three foreign flag tankers. Table XVI was derived from data in Table XV, however, total annual component shipping costs are expressed as a percentage of the total annual shipping cost for the various size tankers. It should be noted insurance costs for both hull and machinery (H&M) and protection and indemnity (P&I) and fuel costs increase as a percentage of total cost as tanker size increases. All other costs tend to be a lower percentage of the total cost as tanker size increases. Table XVI is the most useful for analyzing the various cost components per thousand DWT as tanker size increases. When expressed in terms of cost per thousand DWT all cost components decrease as tanker size increases. This table reveals that nearly half the difference in total annual cost per DWT between a 40,000 and 120,000 DWT tanker is due to construction cost economies. Another third of the difference is due to the larger tankers lower crew and fuel costs. In analyzing the difference between a 120,000 and 300,000 DWT tanker, the cost differences are much less significant, however, the same three component costs are still the primary economies as tanker size increases.

The second analysis of transportation economies available via progressively larger "super" bulk carriers is based on a study conducted by IHI of Japan. The summary of this study is shown on Drawing 11. No cost information was made available by IHI, most likely, for proprietary reasons. The drawing indicates that transportation costs per tanker DWT gradually decrease as tanker size increases up to approximately 800,000 DWT. The incremental cost change between 600,000 and 800,000 DWT is relatively minor in comparison to the change between 200,000 and 400,000 DWT. As noted earlier, due to technical considerations, IHI recommends shifting to a twin propeller means of propulsion when ship size reaches 800,000 DWT. As shown on the drawing, the cost curve has a break and moves significantly higher above 800,000 DWT. The per unit transportation cost for a 800,000 DWT tanker with twin propellers appears to be very comparable to a 400,000 DWT tanker with single propeller propulsion. For this reason IHI does not believe it will be economically practical with present technology to build a tanker above 800,000 DWT. [Ref. 16, p. 28]

The third analysis of transportation economies available via progressively larger "super" bulk carriers is based on the Standard Oil of New Jersey study referenced to previously. This analysis used the base case method of a 50,000 DWT carrier. A relative transportation cost of 100% is assigned. (See Drawing 12.) The transportation cost represents the total per unit transportation cost to transport

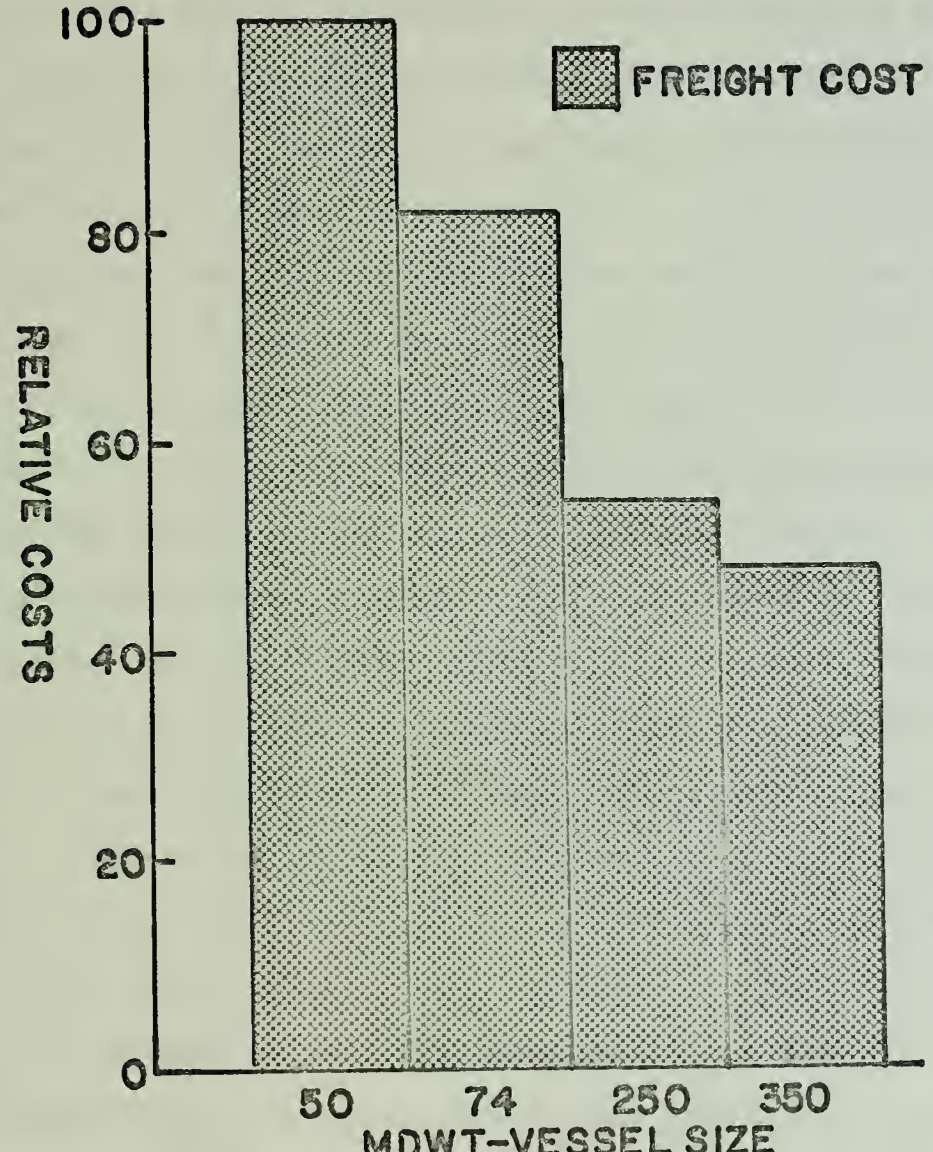
Drawing 11. Analysis of Tanker Transportation Cost (per DWT)



Note: S.B.T. - segregated ballast tanks (required on new construction above 80,000 DWT after 1980 as per 1973 Intergovernmental Maritime Consultive Organization Convention.)
d - draft in meters

Source: Dr. Tsunco Kuniyasa, "Are Million-Ton Tankers Practical?" Ocean Industry, Vol. 9 No. 3, (March 1974), p. 28.

Drawing 12. Relative Transportation Cost Analysis, Persian Gulf/East Coast, Suez Canal Closed.

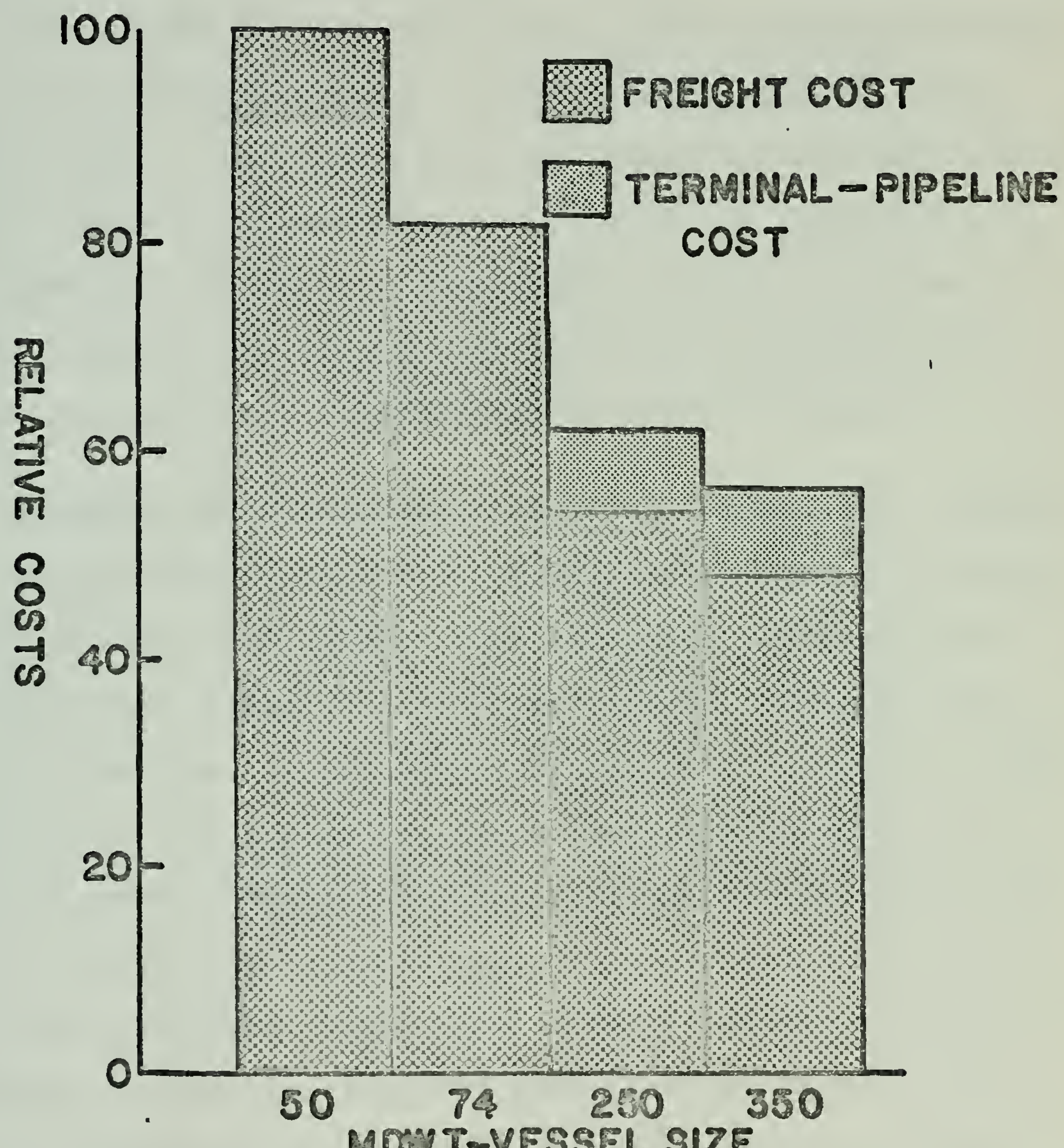


Source: Christopher J. Carven, "Petroleum Transportation Economics," Mammoth Tankers, Deepwater Ports and the Environment, printed proceedings of May 18, 1972 meeting sponsored by the Eastern Region of the Maritime Administration and the Propeller Club of the Port of New York.

one unit of petroleum from the Persian Gulf around the Cape to the east coast of the United States. The transportation cost includes costs for both legs of the voyage, operating costs (wages, repairs, insurance, port charges, and bulker fuel costs), and capital recovery costs. Recovery costs are keyed to the initial investment costs indicated on Drawing 7. A nominal discounted cash flow of 10% return on total capital for a 20 year period was used as the basis for determining capital recovery costs.

As indicated on the drawing the relative transportation cost per unit decreases as tanker capacity in DWT increases. The relative transportation cost per unit for the 350,000 DWT tanker is less than half the transportation cost of the 50,000 DWT tanker. (The figure is actually 48%.) Drawing 13 indicates the additional per unit increase in the transportation costs if capital recovery costs for a terminal and associated distribution pipeline system were installed to receive fuel from the 350,000 and 250,000 DWT tanker. A capital recovery cost of 6.5 cents per barrel for the terminal and 5.5 cents per barrel for the pipeline system is included. These figures were derived from an industrial study to install a terminal inside Delaware Bay. A daily throughput of 1.7 million barrels was assumed. As indicated on the drawing the relative transportation cost per unit for the 350,000 DWT tanker is approximately 60% of the cost for the 50,000 DWT tanker.

Drawing 13. Relative Transportation Cost Analysis, Persian Gulf/East Coast, Suez Canal Closed, Utilizing Terminal.



Source: Christopher J. Carven, "Petroleum Transportation Economics," Mammoth Tankers, Deepwater Ports and the Environemnt, printed proceedings of May 18, 1972 meeting sponsored by the Eastern Region of the Maritime Administration and the Propeller Club of New York.

Drawing 14 carries the previous analysis one step further. All previously discussed assumptions apply, with the exception that the Suez Canal is now assumed to be open. Both the 50,000 and the 74,000 DWT tankers may now transit the Suez Canal on each leg of the voyage. The 250,000 and the 350,000 DWT tankers must still transit around the Cape but will transit the Suez on the ballast leg back to the Persian Gulf. The appropriate toll charges have been added to the relative transportation costs.[10] As indicated on the drawing, all relative transportation costs are now reduced, however, the 350,000 DWT tanker still provides the least cost means of transporting the unit of oil.

C. ECONOMIES OF DRY AND MULTI-PURPOSE "SUPER" BULK CARRIERS

The previous two sections have dealt primarily with the construction and transportation economies available via progressively larger "super" bulk tankers. However, the Soros Associates study of construction cost economies available via larger dry and multi-purpose bulk carriers was briefly summarized in the first section. Nathan Associates did not conduct a separate computer parametric transportation cost study for either dry or multi-purpose bulk carriers. A study of these two types of bulk carriers revealed that cost differences were "very modest" and the basic design

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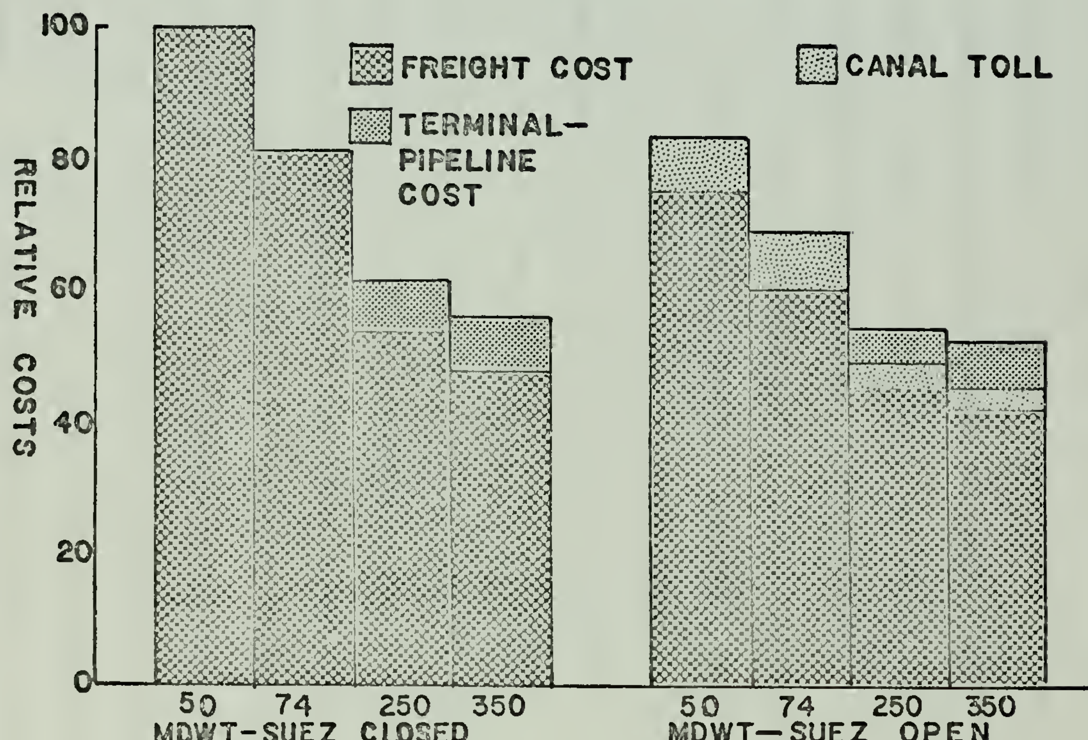
[10] "The canal tolls are based on the pre-closure levels escalated at the rate of 1% per year. This rate is based on the 1957 agreement the Egyptian Government made with the U.S. at the time the Canal was nationalized." [Ref. 19, p. 18]

Source: Christopher J. Carven, "Petroleum Transportation Economics," Mammoth Tankers, Deepwater Ports and the Environment, printed proceedings of May 18, 1972 meeting sponsored by the Eastern Region of the Maritime Administration and the Propeller Club of the Port of New York.



Drawing 14. Relative Transportation Cost Analysis, Persian Gulf/East Coast, Suez Canal Open, Utilizing Terminal.

and operating features of all bulk carriers were generally similar. The major differences discovered were the internal arrangements and design of the cargo holds. The cost to construct either a dry or a multi-purpose bulk carrier was found to be relatively higher than a comparable size tanker. (See Table XVIII.) Although the cost to operate and maintain a multi-purpose bulk carrier was found to be higher than either a tanker or dry bulk carrier, the transportation cost for the multi-purpose bulk carrier was found to be less. This is due to the higher load factor available with multi-purpose bulk carriers. Tankers and dry bulk carriers typically have a load factor of 50%, however, it is not uncommon for a multi-purpose bulk carrier to have a load factor above 60%. [Ref. 3, Vol. V, p. 145]

The additional flexibility and utilization available via the multi-purpose bulk carriers has enabled this type of vessel to serve multiple markets. As indicated earlier by the number of multi-purpose bulk carriers on order and under construction this type vessel is becoming progressively more popular. Due to the volatile nature of the bulk shipping business bulk rates fluctuate as demand for various bulk commodities changes. Multi-purpose bulk carriers allow maximum flexibility to enter the most profitable markets.

Table XVIII. Investment Cost Relationships of Tankers, Dry Bulk Vessels, and Combined Carriers of Equal Deadweight

Type of Vessel	Index Number
Conventional tanker.......	100
Dry bulk carrier..........	103-4 104
Single stowage factor...	X
Multiple stowage factor.	1.03X
Combined carrier	
Ore/oil (O/O)...........	109 108 1.05X
Ore/coal/oil (SOCO).....	110-111
Bulk[a]/oil (B/O)........	108X
Ore/bulk/oil (O/B/O)....	116 115

a/ Low density

Source: Robert R. Nathan Associates, U.S. Deepwater Port Study, prepared for U.S. Army Corps of Engineers, Institute of Water Resources, 1972, Vol. V, p. 147.

VII. THE CONSEQUENCES OF A FAILURE TO PROVIDE UNITED STATES FACILITIES TO ACCOMMODATE "SUPER" BULK CARRIERS

A. HIGHER COST OF IMPORTED BULK MINERAL RESOURCES

As noted previously, the United States is progressively becoming more dependent on foreign countries for the most economical sources of many fuel and non-fuel mineral resources. Not only has reliance on these resources been increasing but the geographic origin has also been shifting toward more remote regions. It appears inevitable, at least in the near future, that the volume of these imported minerals will continue to increase and shipping distances will generally become longer

The technology of the "super" bulk carrier is available to significantly reduce the transportation costs required to ship these commodities. For example, the unit cost per long ton for a 5,000 mile one-way voyage for a 30,000 DWT vessel is approximately $4.00, for a 200,000 DWT vessel $1.70, and for a 500,000 DWT vessel $1.50. Thus a 57.5 percent decrease is possible by using a 200,000 DWT vessel and a 62.5 percent decrease is available by using a 500,000 DWT vessel. [Ref. 3, Vol. I, p. 10] There appears to be no other technology presently available that can provide both the efficiency and flexibility required to transport huge volumes of bulk commodities over long distances.

Basic industry in the United States is the primary consumer of imported mineral resources. At the present time

no U.S. industry is capable of fully capitalizing on transportation economies available via "super" bulk carriers. The U.S. petroleum industry has, to a limited extent, benefited by using "super" tankers to transfer petroleum to smaller tankers or by offloading at foreign transhipment ports located in Canada and the Bahamas. However, the additional cost involved in transferring or transhipping significantly reduce the benefits that would be available if the U.S. could accommodate "super" tankers. In a recent study conducted by Robert R. Nathan Associates petroleum imports to the United States in 1980 were projected to reach approximately 6.9 MM B/D. This forecast is quite conservative, based upon the National Petroleum Council's Case III which projected imports in 1980 to reach 10.3 MM B/D. Case III is generally believed to be the most accurate forecast presently available. However, based on the 6.9 MM B/D figure Nathan Associates predicted that approximately $600 million dollars could be saved annually in reduced transportation costs for petroleum if the United States would provide suitable offloading facilities for "super" tankers.[11] Studies conducted by the Maritime Administration, U.S. Army Corps of Engineers and Soros Associates also arrived at very similar figures.

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[11]The cost savings was in comparison to the costs that would be charged if the maximum size tankers were used at the existing ports without further deepening. All costs and savings are in 1970 dollars. [Ref. 3, Vol. I, p. 10]

To the extent that additional transportation costs are reflected in the delivered cost of imported resources, consumer prices could be expected to rise. Other possibilities are, American consumers would purchase less expensive imported finished goods or the additional costs would be borne by U.S. industry. The market conditions at the time would determine which one or combination of these possibilities would occur.

B. LOSS OF COMPETITIVENESS IN OVERSEAS EXPORT MARKETS

The United States economy depends to a large extent on exports of both finished goods and bulk commodities such as grain, metallurgical coal and phosphate rock. Exported goods have in recent years been accounting for a greater share of the United States gross national product. In order to maintain a competitive position in the foreign market place, U.S. industry has generally incorporated the most efficient production technology. If Japanese and European exporters of finished products can attain an additional margin of efficiency not available to U.S. industry, our competitive position will surely suffer.

U.S. industries which depend on foreign imports of fuel and non-fuel mineral resources do not in general enjoy the margin of efficiency available to similar industries in foreign countries that do have deepwater port facilities. For example, Japan can import both iron ore and coking coal, produce finished steel and ship it to the United States, and compete very favorably in the U.S. market for.

finished steel. A primary reason for the success of Japanese industry has been their utilization of the most efficient technology available. One such technology is the "super" bulk carrier.

The United States is a major exporter of bituminous coal, phosphate rock and grains. These commodities account for the highest tonnage of exports from the United States. The delivered costs of these commodities presently reflect the relatively inefficient means by which they are transported. The ocean transport savings that could be realized by more efficient shipping could accrue to the U.S. exporter in the form of higher profit margins, lowered delivered costs or a combination of both. The foreign market for U.S. exported bulk commodities is generally competitive. To the extent that the delivered cost of U.S. exported bulk commodities is higher than other sources the competitive position of U.S. exporters of bulk commodities will suffer.

C. RELOCATION OF U.S. INDUSTRIES

The inability of United States' ports to accept deep-draft "super" bulk carriers and the resultant higher transportation costs introduces the risk of relocation or closing down of U.S. processing industries. U.S. industry may incur significant competitive disadvantages which could in the long run encourage these industries to seek more favorable locations where they could be served by more efficient means of transportation.

The newly independent country of the Bahamas has developed one deepwater port and is in the process of developing a second. Both will be capable of handling 500,000 DWT tankers. The Bahamas are also expanding their refining facilities and are exporting finished and semi-finished petroleum products to the east coast of the United States. The new government is encouraging foreign investment in industry on a partnership basis with either Bahamians or the Government. Shortly after receiving independence, Prime Minister Pindling's government issued a White Paper on Independence. The Paper indicates that Bahamas' tax-haven status will be maintained and that nationalization will not be an instrument of government economic policy. [Ref. 21, p. 40]

Gulf Oil Company has recently completed a deep-draft tanker and refining complex at Port Tupper, Novia Scotia and is exporting finished and semi-finished petroleum to the east coast of the United States. [Ref. 22, p. 4] The Premier of Nova Scotia, The Honorable G. A. Regan, recently addressed a Seatrade Conference and noted that by expanding refineries in Nova Scotia the United States petroleum industry could solve two major problems. A location which provided facilities to accommodate "super" tankers and a site for new refineries. Mr. Reagan further stated,

> "It is impossible to operate an oil oriented deepwater port without running the risk that some day a spill could occur resulting in serious pollution problems. It is unlikely that provincial governments would be prepared to accept that risk for the minimal economic

activity generated by pure transhipment. The more probable conclusion is that government in any provincial jurisdiction would want to extract at least refining employment in the return for the use of such unique facilities as our deepwater harbours provide." [Ref. 23, p. 458]

The Economic Development Administration of Puerto Rico is developing a deepwater port facility offshore Mona Island and is encouraging U.S. petroleum industries to construct a refining and petro-chemical complex on the island. The Wall Street Journal has recently been carrying advertisements quoting Governor Hernandez-Colon, "Open a plant that provides work for our people and we'll guarantee you no taxes, federal or local."

It is clear that many of this countries' neighbors will readily provide deepwater port facilities, refinery and petro-chemical sites, and tax incentives to U.S. petroleum industries. These offers must sound fairly enticing to industries located in states such as Delaware where expansion is discouraged, deepwater port facilities are not available and, in addition, industries must pay for the installation for expensive pollution control devices.

U.S. based multi-national corporations have no moral commitment to expand in or even to retain plants in the United States. They are presently being penalized in a number of ways, one of which is being forced to use a relatively inefficient mode of transportation, i.e., small bulk carriers. The incentives to relocate are present. Although the petroleum and petro-chemical industries have

been the main subject of this discussion advanced processing of iron ore and bauxite at foreign mines is also taking place. Processing of these ores closer to the source reduces the transportation cost. These processes had, until recently, generally taken place in the United States.

D. BALANCE OF PAYMENTS

The relocation of industry outside the United States may result in a massive outflow of U.S. capital. A similar situation may occur if the United States continues to depend on progressively larger volumes of foreign mineral resources which are transported in relatively small foreign bulk carriers. A loss of U.S. industries' competitive position would also have detrimental effects on the balance of payments and, therefore, on the value of the U.S. dollar. As noted previously this is a possibility if U.S. industry is not provided the opportunity to utilize the most efficient means of transporting large volumes of bulk commodities, i.e., the "super" bulk carrier.

E. PORT CONGESTION AND POLLUTION

As previously noted the U.S. will, most likely, depend on greater volumes of imported bulk mineral resources in the future. If facilities are not provided to accommodate larger bulk carriers then a greater volume of small bulk carriers will be required or less trade will take place. U.S. port facilities will require massive expansion to accommodate the higher volume of small bulk carrier traffic.

With a higher volume of traffic there is also a higher risk of both collisions and grounding which in the case of tankers would mean more oil spills.

The Council on Environmental Quality has recently sponsored a study on oil spills. The Chairman of the Council recently testified in a Congressional hearing,[12]

> "Based on studies conducted for the Council by the U.S. Coast Guard, it appears that creating superports in the United States carries less risk of oil spill damage than does the transhipping and oil from foreign ports. For example, over a 20 year period, at an import level of 2 million barrels per day, we can statistically project approximately 37 vessel casualties resulting in spillage of over 29,000 tons of oil assuming small tankers averaging 50,000 DWT are used to tranship oil from Canadian and Caribbean terminals to conventional U.S. ports. On the other hand, if the same oil were transported direct to U.S. offshore terminals in supertankers averaging 250,000 DWT we can project about four casualties totaling 2,500 tons of oil spilled." [Ref. 24, p. 142]

If 30,000 DWT tankers were used to deliver 3 MM B/D to the U.S. 13 port arrivals per day would be required. Arrivals drop to eight per day if 50,000 DWT tankers are used, one and a half per day if 250,000 DWT tankers are used and to three quarters of an arrival per day if 500,000 DWT tankers are used. Historical data analyzed by the Coast Guard on collisions and groundings demonstrate that most oil spill accidents occur when harbor congestion is great and where maneuvering ships are restricted by narrow winding channels. [Ref. 25, p. 384]

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[12]The study assumed that oil was piped ashore from offshore terminals.

VIII. RECENT EVENTS PERTAINING TO DEEPWATER PORT AND TERMINAL DEVELOPMENT BY THE UNITED STATES

A. MAJOR DEEPWATER PORT AND TERMINAL DEVELOPMENT STUDIES

Since 1970 various federal, state, and private agencies have conducted or sponsored numerous studies associated with deepwater port and terminal development by the United States. Pertinent economic, engineering and environmental factors have been analyzed in detail. The federal agencies that have sponsored and/or conducted major studies are: U.S. Army Corps of Engineers, Maritime Administration, U.S. Coast Guard, Council on Environmental Quality, and the National Oceanic and Atmospheric Administration (NOAA). Although these agencies were directly involved in studies, they also contracted and awarded grants to conduct studies. Major contracts were awarded to management and engineering consulting agencies such as Robert R. Nathan Associates, Soros Associates, and Arthur D. Little, Inc. Grants to study environmental considerations were awarded via the Sea Grant program to the following universities: University of Delaware, Louisiana State University, Massachusetts Institute of Technology, State University of New York at Stony Brook, and the University of Maryland.

The states of Delaware, Texas, Maine, Alabama, and Louisiana are among those that have sponsored deepwater port associated studies. The Delaware Bay Transportation Company, Seadock, and the Louisiana Offshore Oil Port (LOOP) are

among the oil and pipeline consortiums that have also sponsored deepwater port studies. In some instances individual oil and pipeline companies have undertaken major studies.

No attempt will be made to individually summarize all the pertinent studies. A partial list of the major studies has been compiled and included in Appendix A. Although all studies do not agree as to the various economic, engineering and environmental factors there is considerable agreement.

It is generally agreed that the alternative of dredging existing channels and ports is unsatisfactory from an economic, engineering and environmental point of view. The dredging of existing channels to a depth of approximately 75 feet to accommodate 250,000 DWT bulk carriers would undermine many existing structures such as piers, terminals, and bridge supports. Tunnels and underwater pipelines would also require relocation. On the east and Gulf coast rock and/or the continential shelf pose major obstacles to dredging. Channel maintenance and disposal of dredged material would also be very costly. Dredging would also increase the cross sectional area of the existing channels and would introduce a larger volume of salt water into estuaries to the detriment of brackish-water species such as the oyster. Dredging would also jeopardize urban water sources if the acquifer strata was penetrated. In general, alternatives which required no dredging were preferred. However, Robert R. Nathan Associates did consider dredging

at Hampton Roads to be economically justified. Soros Associates also proposed limited dredging but only near the mouth of major bays or offshore. Even if the dredging of major channels could be justified the turning and handling of large vessels within the existing port and channel confines would be very hazardous.

Transhipment of bulk commodities from foreign locations via small bulk carriers was also considered as an alternative. This is presently being done with petroleum from ports in the Bahamas and Canada. Other petroleum transhipment ports are being constructed at locations such as Jamaica and Curaco. Transhipping of oil via foreign ports can be economically justified in some cases. Transhipping oil from an offshore platform via small tankers can also be economically justified based on the present throughput of oil on the east coast and projected throughput on the Gulf and west coast. The transhipment of dry bulk commodities, however, cannot be economically justified from either an offshore platform or via a foreign port. Transhipment of dry bulk commodities was analyzed on both the Gulf and east coast, however, due to relatively low throughput, shorter shipping distances, and high transhipment costs this alternative was judged to be uneconomical. Soros Associates could only justify the construction of an offshore platform for dry bulk commodities if the platform was also used for petroleum.

Even though petroleum transhipment can be economically justified, there are environmental hazards. As previously noted, the volume of imported petroleum is predicted to significantly increase in the future. Petroleum transhipment from either an offshore platform or a foreign port will require the use of small tankers, approximately 65,000 DWT. To handle the increased volume of petroleum a large fleet of small tankers will be required. The increased traffic in already congested shipping lanes and ports will undoubtedly lead to an increased number of groundings, collisions, and oil spills. For this reason transhipment via a fleet of small tankers has been judged to be an inferior alternative.

The practice of lightening "super" tankers to small tankers or barges was also considered as an alternative. Lightening is only possible in protected harbors or in calm seas, however, this practice is being used on all three coasts. There have recently been strong protests against lightening in protected harbors. Since lightening is a form of transhipment and does not solve the problem of congestion in shipping lanes, ports and channels it was considered to be an inferior alternative.

Offshore deepwater port development with a submerged pipeline to shore was considered to be the best alternative from both an economic and environmental viewpoint. Offshore development was found to be economically justified on the east coast based on the present throughput of petroleum

and on the Gulf and west coast based on projected throughput. Various designs for fixed platforms, single point mooring buoys, and storage islands were analyzed. All proved to be financially attractive. In general, the single point mooring buoy was found to be the least expensive alternative. The most expensive alternative, but also the best design from an environmental point of view, was that of Soros Associates. (See Drawings 15, 16, and 17.)

The U.S. Coast Guard conducted an analysis of casualty oil spills for the Council on Environmental Quality. The study revealed that the number of polluting tanker casualties and the total oil spilled would be less from "super" tankers averaging 250,000 DWT serving offshore deepwater ports than from tankers averaging 50,000 DWT serving conventional ports.[13]

NOAA awarded grants to five universities to analyze the environmental effects of oil spills, construction, and operations from port development at a number of locations on the east and Gulf coasts. The studies revealed the vulnerability to environmental damage from deepwater port development was likely to be the greatest at inshore locations, particularly those involving massive dredging, and less at offshore locations. Estuaries and coastal wetlands were found to be the most biologically productive and also the

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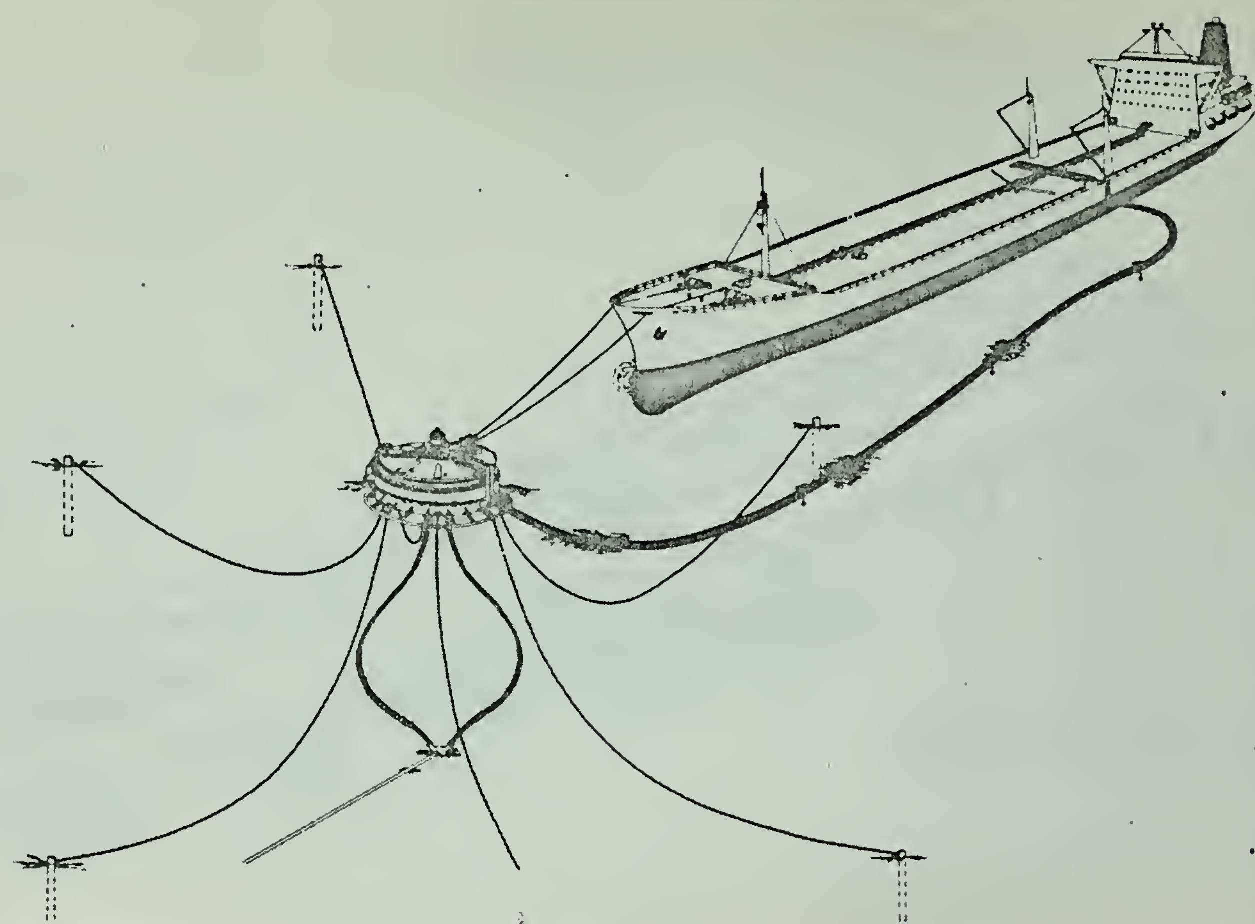
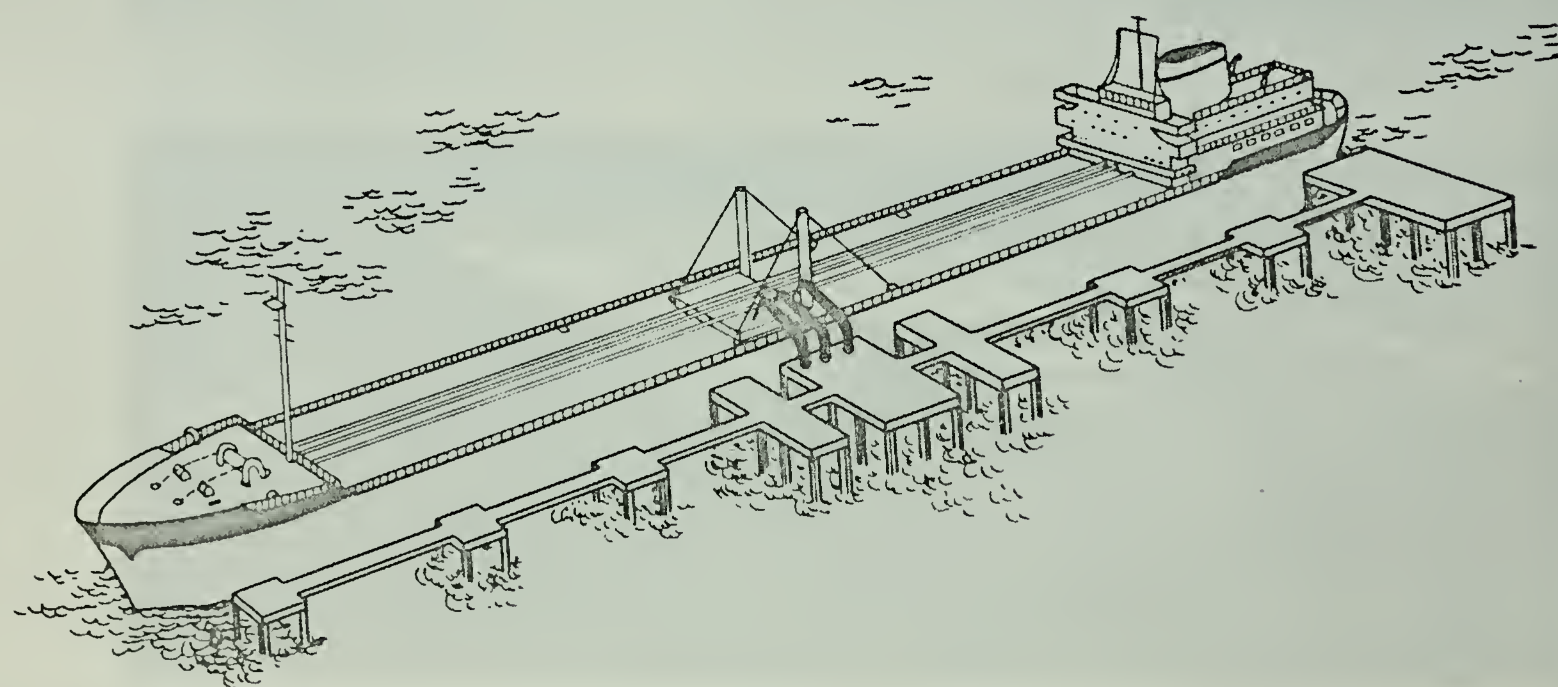
[13]Key assumptions - the same amount of oil was transferred and oil was transported ashore from the offshore port via pipeline.

Drawing 15. Single Point Mooring Buoy.



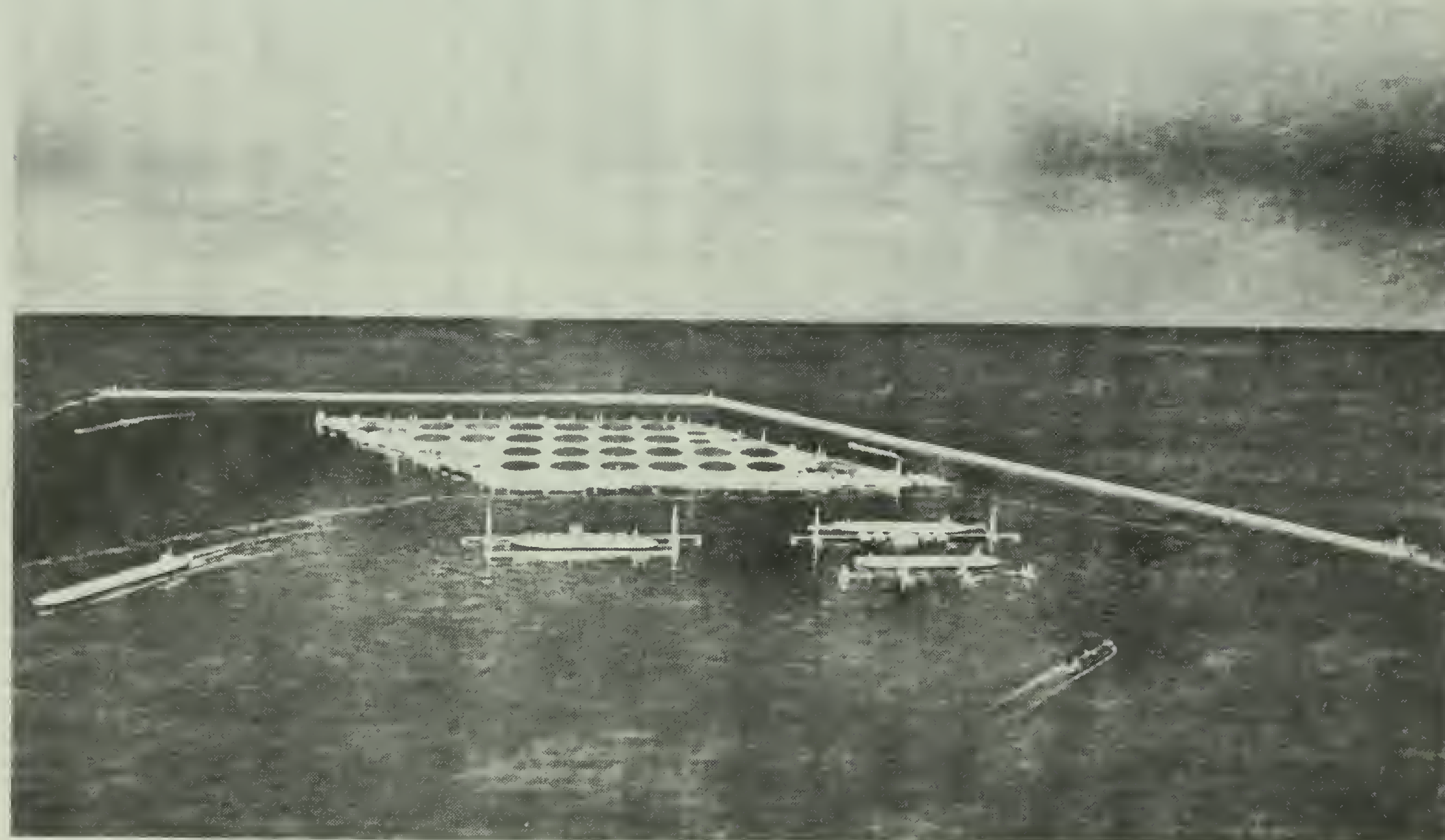
Source: Dan M. Bragg and James R. Bradley, Work Plan For A Study of the Feasibility of an Offshore Terminal in the Texas Gulf Coast Region, Texas A&M University, June 1971, p. 12.

Drawing 16. Offshore Fixed Platform.



Source: Dan M. Bragg and James R. Bradley, Work Plan For A Study of the Feasibility of an Offshore Terminal in the Texas Gulf Coast Region, Texas A & M University, June 1971, p. 13.

Drawing 17. North Atlantic Deepwater Oil Terminal (NADOT)



Source: Soros Associates, Inc. Offshore Terminal System Concepts, prepared for the U.S. Department of Commerce, Maritime Administration, September 1972, Executive Summary, p. 3.

most sensitive to oil spill effects. There was a general consensus that if tankers transited close to the coast and in restricted waters there was a higher probability of unavoidable ecological and recreational damage from oil spill effects. At offshore locations it was concluded that construction effects were minimized and the probability of an oil spill reaching sensitive estuarine areas was greatly reduced.

The environmental effects of deepwater port development are not limited to the marine environment since industrial expansion onshore would, most likely, result. The environmental effects from industrial activity onshore if not properly controlled could prove to be a greater detriment to the environment than the construction and operation of an offshore oil port. Studies undertaken indicate the construction of only one deepwater port on each coast would tend to maximize the transportation savings but would likely result in the highest social and environmental costs. These costs would be highest in areas which are already densely populated, heavily industrialized, stressed by pollution, or used as recreational areas. Land use decisions will be of primary importance in determining the location of deepwater port development. Locations should be selected where regional economic benefits are needed and where associated environmental impacts might be better tolerated.

B. LEGISLATION TO PROVIDE FOR LICENSING OF DEEPWATER PORT AND TERMINAL DEVELOPMENT AND OPERATION

At the present time there is no authorizing legislation which would permit the construction of an offshore deepwater port beyond the three mile limit. States have primary jurisdiction over the area from their shorelines out to the three mile limit. The states of California and New York have authorized the installation of a limited number of offshore terminals, however, the largest of these facilities are limited to serving tankers up to 130,000 DWT. There are approximately six bills before Congress to provide for the construction and operation of deepwater ports beyond the three mile limit. The major disagreements are on issues of environmental protection, state control, and federal agency responsibility for control of deepwater port facilities. The administration backed bills are HR 7501 and S 1751. These bills would permit the Secretary of the Interior to issue licenses for the construction and operation of offshore deepwater ports beyond the three mile limit. The Secretary would be required to consult with the governors of offshore states to insure that the operation of the facility and related land based activities were consistent with the state land use program.

C. DEEPWATER PORT AND TERMINAL DEVELOPMENT

1. East Coast of the United States

Numerous attempts have been made by individual or consortiums of oil and pipeline companies to develop deepwater

ports and terminals for crude oil on the east coast. Two of the first proposed were the Machiasport Oil Refinery and the Delaware Bay Transportation Company projects. Both were initially proposed in the late 'sixties and early 'seventies. Since construction was within the three mile limit the states of Maine and Delaware could have authorized development after the proposals met various federal agency requirements. Maine's Environmental Improvement Commission recommended rejecting the Machiasport project and the passage of the Delaware Coastal Zone Act of 1971 prohibited the construction of any offshore deepwater port or terminal. Delaware's Coastal Zone Act has recently come under heavy criticism by the building trades, Delaware Chamber of Commerce, DuPont Co., the 13 companies that make up the Delaware Bay Transportation Company, and even from the state appointed Delaware Bay Oil Transport Committee.

Additional proposals for deepwater port development have been submitted by the Bayside Pipeline Co. and the Intercontinental Pipeline Co. The Bayside facility would permit unloading of "super" tankers near the mouth of Delaware Bay. Oil would then be piped to refineries on the Delaware River and the Arthur Kill areas. The pipeline would be located on the New Jersey side of Delaware Bay. The Intercontinental Pipeline Co. proposal is for the construction of a facility 36 miles south of Cape May. The submerged pipeline would come ashore in New Jersey and oil would be piped to refineries in the Philadelphia and New

York area. At present neither of these facilities can go beyond the planning and design stage since both would be located beyond the three mile limit.

Another recently proposed deepwater port facility was rejected by the town of Durham and the state of New Hampshire. Olympic Refineries, Inc., an Onassis' firm, had proposed construction of a $600 million oil refinery and deepwater port. Even with strong backing from the Governor, the town and the state legislature both rejected the proposal. The Coastal Plains Regional Commission (states of North Carolina, South Carolina and Georgia) have recently joined with seven major oil companies to conduct an economic and environmental feasibility study for the construction of an offshore deepwater port in that region.

Although the east coast of the United States, and in particular the northeastern region, has the highest economic need for deepwater facilities. There has been no significant progress due to strong environmental opposition. Environmentalists are concerned not only with the marine environment but also the onshore environment since industrial development would, most likely, accompany deepwater port development.

2. Gulf Coast of the United States

Numerous Gulf coast states have encouraged oil and pipeline consortiums to construct offshore deepwater ports and terminals. At the present time three major facilities are in the planning stage. In Louisiana, a consortium of

13 oil and pipeline companies known as LOOP, Inc. (Louisiana Offshore Oil Platform) has completed extensive economic, engineering, and environmental studies. Final design and a more detailed environmental study are presently being conducted. The initial facility would be located approximately 21 miles offshore of LaFourche Parish, La. It would consist of three single point mooring buoys, pumping platforms, and two pipelines (48 inches by 56 inches) 21 miles long. The onshore facility would consist of a storage facility and pipeline from LaFourche Parish to the St. James, La. terminal of Capline. In a later stage of development two additional buoys and three submerged pipelines would be added. Upon completion of the last stage the facility would be capable of receiving approximately 4 MM B/D. Refineries in eastern Louisiana, Mississippi, Arkansas, Tennessee, Missouri, Kentucky, Illinois, Indiana, Ohio, and Michigan would be supplied via the LOOP and Capline facility. Cost estimates are (in 1972 dollars) $150 million for the offshore facility and submerged pipelines. One hundred thirty million dollars for the storage facility located onshore, and $88 million for the pipeline to connect the storage facility to Capline. [Ref. 26, p. 299-375]

In Texas, 11 oil companies and one petro-chemical company have formed a consortium known as Seadock. The Seadock facility is very similar to LOOP. Seadock's facility would consist of three single point mooring buoys

located 25 to 30 miles off the coast of Freeport, Texas. Submerged pipelines and an onshore oil storage and pipeline network would also be constructed. The facility would supply crude petroleum to refineries in western Louisiana, Texas, and possibly the midwest. The Seadock facility would be capable of receiving approximately 3 MM B/D. The total Seadock initial investment has been estimated to be approximately $545 million.

The states of Alabama and Mississippi have formed an organization known as Ameraport Corporation. Ameraport has sponsored both environmental and economic studies pertaining to deepwater port development at a location approximately 26 miles offshore the Mobile-Pascagoula area. Ameraport has been actively publicizing the benefits of developing an offshore deepwater port, oil refineries, and petro-chemical plants in the states of Alabama and Mississippi. However, to date the Ameraport project has met with very limited success.

The ports of Galveston and Corpus Christi have recently initiated a campaign to gain approval for massive dredging operations to provide for land based deepwater port facilities. Studies conducted by these ports indicate the economic benefits of providing facilities for both liquid and dry bulk commodities are greater than the cost of dredging operations which would be required.[14]

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[14]These studies have not been reviewed by the author and it is unknown if social and environment costs were included.

Olympic Refineries, Inc. are still looking for a location to build a $600 million refinery and a deepwater port. Although this Onassis' project was recently rejected in the state of New Hampshire, the states along the Gulf coast have been proposed as possible locations. As of this writing, Olympic Refineries has not yet made a firm proposal. The states of Texas, Louisiana, Mississippi, and Alabama are under active consideration.

3. <u>West Coast of the United States</u>

As previously noted, there are approximately 19 offshore oil terminals along the coast of California, however, none of these facilities is considered to be a deepwater facility since the largest tanker that can presently be accommodated is 130,000 DWT. There is at present only one major deepwater facility proposal for the west coast. The Standard Oil Company of California has recently completed a six-month site and geographical evaluation at a proposed location offshore Estero Bay. The location is within the three mile limit and would consist of a single point mooring buoy and a submerged pipeline. Oil would be pumped ashore to storage tanks and then to Standard's Richmond Bay refinery. The facility would accommodate tankers up to approximately 400,000 DWT and would be capable of receiving approximately 0.5 MM B/D.

IX. CONCLUSIONS

The United States is becoming a "have not" nation for the most economical source of many fuel and non-fuel mineral resources required by U.S. industry. The three bulk resources which will, most likely, by required in the largest volume are crude petroleum, iron ore, and alumina/bauxite. The trend toward greater dependence on foreign sources for these and many other resources is certain to increase in the future. There is a general trend in the geographic origin of many of these imported resources toward more remote regions and thus, shipping distances are increasing. The most economical means of transporting large volumes of these and other bulk commodities is via "super" bulk carriers.

Since the early 'sixties the capacity of ocean bulk carriers has been steadily increasing. "Super" tankers with a capacity of 477,000 DWT (3.5 million barrels) are presently in service and a 706,000 DWT "super" tanker is under construction contract. The capacity of both dry and multi-purpose bulk carriers has also been steadily increasing. The largest of these ships is 280,000 DWT and carriers as large as 400,000 DWT are expected in the near future.

With a few exceptions ports in the United States can only accommodate vessels with a capacity between 65,000 and 80,000 DWT. Recent deepwater port studies indicate the best alternative for providing facilities for "super"

tankers is via offshore deepwater development. This alternative was found to be the most preferable from both economic and environmental viewpoints. Offshore deepwater port development for receipt of crude petroleum was found to be economically justified based on the present throughput of oceanborne petroleum on the east coast and projected oceanborne petroleum throughput on the Gulf and west coast.

Deepwater port studies indicate the construction of offshore deepwater port facilities for the receipt and shipment of dry bulk commodities is not economically justified. Dry bulk commodities require transhipment and a large offshore storage and transhipment platform would be necessary. Slurry technology may be an alternative to constructing such a facility, thus no transhipment would be required. Slurry technology is being used by the Marcona Corp. to ship iron sands concentrates from New Zealand's North Island to Japan. The slurry can be loaded and offloaded via a single point mooring buoy, however, Marcona is only using this method to onload at present. Slurry technology is also been successfully used to transport coal via pipeline. The Maritime Administration has recently sponsored research for slurrying of coal, iron ore, bauxite/alumina and phosphate. Slurry technology, if found to be suitable for these commodities, may significantly lower the initial investment and operation costs so that offshore deepwater port development for dry bulk commodities may also be justified. Further research is required.

Private industry in the United States has not been successful in their numerous attempts to develop suitable offshore deepwater facilities to receive crude petroleum from "super" tankers. Private proposals on the east coast have been rejected for environmental reasons, however, this coast has the highest industrial need for such facilities. Gulf coast states have encouraged private offshore deepwater port facilities for the receipt of petroleum. Due to "institutional drag" and the lack of authorizing legislation all proposals are at a standstill. There has been only one deepwater facility proposed on the west coast and this facility would be located within the three mile limit.

Numerous public and private agencies have conducted studies which examine the need for deepwater ports and alternative solutions to deepwater port problems and requirements. Although most studies have considered the environmental impacts and social implications of deepwater port development none have succeeded in quantifying environmental and social costs. The total economic costs and benefits have not been identified due to the present limitations in techniques of economic analysis. These social and environmental costs may, however, be reduced by judicious land use planning and pollution control technology. One solution would be to locate deepwater terminals for receipt of crude petroleum and new refining capacity in regions where industrial benefits are desired and where the associated environmental and social costs could be reduced and tolerated. Construction

of deepwater terminals to service existing refineries, which have a high throughput of oceanborne crude petroleum, appears to be the best solution from both an economic and environmental point of view.

A failure to provide United States facilities to accommodate "super" tankers and, when economically justified, "super" dry and multi-purpose bulk carriers will have far reaching effects on U.S. industry, the cost of living, balance of payments and the environment. Compelling evidence is at hand which implies, if the United States is to maintain its status as a leading economic power the technological efficiency of "super" bulk carriers should be utilized.

APPENDIX A: LISTING OF MAJOR DEEPWATER PORT AND TERMINAL DEVELOPMENT STUDIES

I. ECONOMIC, ENGINEERING, AND ENVIRONMENTAL STUDIES

Arthur D. Little, Inc., Foreign Deepwater Port Developments-A Selective Overview of Economics, Engineering and Environmental Factors, prepared for U.S. Army Corps of Engineers, Institute for Water Resources, December 1971, (IWR-Report 71-11)

- Vol. I. - Summary
- Vol. II. - Appendix A - France, Dunkirk and Leharve
  - Appendix B - Belgium, Antwerp
  - Appendix C - The Netherlands, Rotterdam and Amsterdam
- Vol. III. - Appendix D - United Kingdom
  - Appendix E - Canada, Port Carter
  - Appendix F - Australia
  - Appendix G - Japan
  - Appendix H - The Persian Gulf
  - Appendix I - Bantry Bay, Ireland

Robert R. Nathan Associates, Inc., U.S. Deepwater Port Study prepared for U.S. Army Corps of Engineers, Institute for Water Resources, August 1972. (IWR Report 72-8)

- Vol. I. - Summary Report
- Vol. II. - Commodity Studies and Projections
- Vol. III. - Physical Coast and Port Characteristics, and Selected Deepwater Port Alternatives
- Vol. IV. - The Environmental and Ecological Aspects of Deepwater Ports
- Vol. V. - Transport of Bulk Commodities and Benefit-Cost Relationships

Soros Associates, Inc. Offshore Terminal System Concepts, prepared for U.S. Department of Commerce, Maritime Administration, September 1972.

- Part 1 - Evaluation of Requirements and Capabilities for Determination of the Need for Offshore Terminals
- Part 2 - Connections Between Deep-Draft Terminals and Existing Facilities by Utilization of Feeder Vessels, Pipelines and/or Shore Facilities Relocation
- Part 3 - Formulation of Advanced Concepts for Offshore Terminals
- Part 4 - Executive Summary

U.S. Department of Commerce, Maritime Administration, The Economics of Deepwater Terminals, Government Printing Office, 1972

II. ECONOMIC AND ENVIRONMENTAL STUDIES

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L. Eugene Cronin, et al Preliminary Analysis of the Environmental Aspects of Deep Port Creation and Supership Operation, Natural Resources Institute, University of Maryland prepared for U.S. Army Corps of Engineers, Institute for Water Resources, July 1971, (IWR Report 71-10).

J. L. McHugh, et al, Possible Effects of Construction and Operation of a Supertanker Terminal on the Marine Environment in New York Bight, State University of New York, Stony Brook, Marine Sciences Research Center, prepared for Council on Environmental Quality, November 1972.

Don Maurer, et al, Environmental Vulnerability of the Delaware Bay Area to Super Tanker Accommodation, University of Delaware, College of Marine Studies, prepared for Council on Environmental Quality, February 1973.
Vol. I - Summary
Vol. II - Biology, Volume
Vol. III - Chemistry, Engineering, Geology, Physical Oceanography
Vol. IV - Biology Appendix

Stephen F. Moore, Robert L. Dwyer and Arthur M. Katz, A Preliminary Assessment of the Environmental Vulnerability of Machias Bay, Maine to Oil Supertankers, Massachusetts Institute of Technology, prepared for National Oceanic and Atmospheric Administration, January 1973.

George A. Rounsefell, Ecological Effects of Offshore Construction, University of Alabama, Marine Science Institute, prepared for U.S. Army Corps of Engineers, Coastal Research Center, 1972.

Wesley P. James, et al, Environmental Aspects of a Supertanker Port on the Texas Gulf Coast, Texas A&M University, prepared for National Oceanic and Atmospheric Administration, December 1972.

IV. MISCELLANEOUS DEEPWATER PORT DEVELOPMENT ASSOCIATED STUDIES

Steward Borland and Martha Oliver, Port Expansion in the Puget Sound Region 1970-2000, University of Washington, Division of Marine Resources, prepared for National Oceanic and Atmospheric Administration, October 1972.

Danial M. Bragg, et al, Work Plan for a Study of the Feasibility of an Offshore Terminal in the Texas Gulf Coast, Texas A&M Univeristy, June 1971.

Danial M. Bragg and James R. Bradley, The Economic Impact of a Deepwater Terminal in Texas, Texas A&M University, prepared for National Oceanic and Atmospheric Administration, November 1972.

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Ernst Frankel, Studies on the Future of Atlantic Ports, Massachusetts Institute of Technology, prepared for National Oceanic and Atmospheric Administration, July 1973.

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